ACSC/DEW/021/95-05

ADVANCED COMBAT TIMELINE (ACT)

FOR THE AIR FORCE COMMAND EXERCISE SYSTEM (ACES)

A Research Paper

Presented To

The Directorate of Research

Air Command and Staff College

In Partial Fulfillment of the Graduation Requirements of ACSC

by

Major Milan Celko
Lieutenant Commander Richard DuBois
Major Scott Goehring
Major Michael McNeely
Major Michael Webb

May 1995

New Text Document.txt

30 July 97

POC: Air Command and Staff College
Air University
Maxwell AFB, Al. 36112

Disclaimer

The views expressed in this academic research paper are those of the authors and do not reflect the official policy or position of the U.S. Government, the U.S. Department of Defense, the Government of the Slovak Republic, or the Slovak Ministry of Defense.

Preface

This research project provided a blend of important subject matter, tangible consequence, and the simple joy of creation. In seeking to improve the Air Force Command Exercise System (ACES), the research team knew that it could make important improvements to a widely used educational tool. To move ACES from its tactical origins toward a truly operational level simulation seemed a particularly relevant and important contribution to airpower education. To know that our recommended changes will be incorporated provides the reward of tangible consequence, and to have achieved all this while having fun reflects the simple joy of creation. We are grateful for having participated in the Air Command and Staff College research program.

The research team would like to express sincere appreciation to the several key people who made this effort possible: Major Mike Bland, Major Mike Loftus, Captain Scott Matthes, and Dr. E. L. Perry. We must give a special note of thanks to Captain Karl Mathias for providing invaluable technical assistance and Lieutenant Colonel Gary *Mo* Morgan for advising the effort. All of these people contributed to make this an enjoyable and successful research project.

Table of Contents

List of Figures

List of Tables

Abstract

Sponsored by the Air Force Wargaming Institute (AFWI), this research developed improvements to the Air Force Command Exercise System (ACES), a wargame model used extensively in the education of air campaign planning. The research addressed two major limitations of the model: (1) an inability to simulate time increments longer than 24 hours and (2) a minimal simulation of naval action. Alleviating these limitations, the Advanced Combat Timeline (ACT) for ACES should significantly enhance the model's ability to simulate the operational level of war.

In pursuing these improvements, the research team clarified the model's educational objectives, analyzed its current data structure, and designed changes to effect the desired capabilities. A review of relevant literature provided criteria by which to evaluate the proposed changes. To ensure the efforts' effectiveness, the research team conducted its activities in close coordination with AFWI personnel.

The resulting recommended changes to the ACES wargame model include: (1) a methodology by which players can translate general operational objectives into specific rules for force employment; (2) decision criteria such that the simulation results remain within reasonable, practicable bounds; and (3) a description of relevant naval weapon systems, their operational characteristics, and rules for their employment. AFWI programmers will use the research results as a blueprint to modify the model software. The resulting changes will enhance the ACES model's representation of the operational level of war and improve its utility in airpower education.

ADVANCED COMBAT TIMELINE (ACT)

FOR THE AIR FORCE COMMAND EXERCISE SYSTEM (ACES)

Chapter 1

Background and Statement of the Problem

Introduction

As Chairman of the Joint Chiefs of Staff, General Colin Powell recognized an important application of computer technologies: "Today, modeling and simulation are essential tools for training."[1] The Air Force Wargaming Institute (AFWI) provides such tools for education and training in the application of airpower. Chief among these tools, the Air Force Command Exercise System (ACES) presents a computer-assisted learning environment for air campaign planning and execution. This research effort seeks to improve the ACES model by enhancing its ability to simulate the operational level of warfare. AFWI sponsored this project, the Advanced Combat Timeline (ACT) for ACES, to increase the model's utility in airpower education and training.

Overview

The ACT project represents an effort to capture the complex human logic of military campaign planning in a form that can be incorporated into the ACES computer model. To convey the motive and nature of this research, Chapter 1 provides background information on the ACES model and defines specific problems addressed in the ACT project. To clarify the research issues, Chapter 2 reviews relevant literature and surveys current wargame models. Chapter 3 then outlines the specific methodology used in this project, while Chapter 4 provides a detailed analysis of the current ACES data structure. Chapters 5 and 6 present recommended changes to the ACES wargame model, and Chapter 7 concludes the report by evaluating those proposed changes. All this work depends critically on the nature and use of the ACES wargame model.

Background

ACES is a computer-assisted, theater-level wargame used in professional military education (PME) to aid the instruction of campaign planning. The wargame provides students an exercise medium in which to develop and execute theater campaign plans that integrate air, land, and sea forces. Players have the opportunity to apply classroom learning by working through the campaign planning process and evaluating their work in a simulated conflict. "ACES is designed to reinforce principles and concepts taught at intermediate and senior service schools."[2] Current users of the ACES model include the Air Command and Staff College (ACSC), Air War College International Officers, Royal Air Force Staff College, and the Canadian Armed Forces Combined Staff College. In 1996, the Army Command and General Staff College will also begin using the model.

The ACES model simulates a notional war; two opposing teams analyze a scenario, build campaign plans, and execute their plans. Player actions follow three distinct phases: (1) planning, (2) sortie allocation, and (3) land order input.[3] In the planning phase, each team analyzes a given scenario, develops a strategy, and builds a campaign plan. Players conclude the planning phase by deploying forces to the theater, posturing those forces, and determining the logistical requirements to sustain operations.

With forces in place, the sortie allocation phase begins. Each team tasks their assigned air assets to missions that support their respective campaign plans. Players accomplish this tasking by building a simplified air tasking order (ATO). The land order input phase facilitates similar taskings for ground forces; players define all movement and employment actions for their assigned ground forces. The information developed in these three phases provides the input that enables the ACES model to simulate combat.

Using the input provided, the current ACES model simulates 24 hours of combat. The computer adjudicates the opposing plans and calculates the results of force-on-force engagements. The model provides its results in a series of formatted output reports and updated screen displays, which the players analyze to repeat the process for another day of war. As the ACES software executes the combat simulation and report generation in batch processing on a Cyber 962 mainframe computer, exercise play is normally restricted to one day of simulated war for each day of real time.

Statement of the Problem

The current version of the ACES model, ACES 1.0, exhibits two significant limitations. First, the model cannot simulate time increments longer than 24 hours. Participants plan for each day of battle, provide input to the computer, and wait for results from the day's action. As the software is executed in mainframe processing, play is normally restricted to one day of simulated war for each day of real time. Most PME curricula can allocate only a few days to the exercise, and thus, the simulated war is just getting started as the time allotted for the exercise ends. Without the opportunity to examine the further progress of a conflict, students rarely experience the consequences of their decisions, the effectiveness of their plans, or the role of sustainment at the operational level of war. To properly support these educational objectives, the ACES model must simulate time increments longer than 24 hours.

The model's second significant limitation is its minimal simulation of naval action. An aircraft carrier in the game serves merely as a fixed location from which to launch air sorties. No other naval weapon systems or missions can be executed from the sea. This represents a deficiency in the game's ability to portray joint force application. To facilitate training in joint force campaign planning, the ACES model requires a more robust and realistic simulation of naval forces.

AFWI sponsored this research project to address these two major limitations of the ACES wargame and increase the model's utility in the education of operational campaign planning. The central research problem was to develop the logic requirements and design criteria for software modifications necessary to incorporate flexible time step simulation capabilities and realistic naval force actions into the ACES model. AFWI software programmers will use the research results to make the necessary modifications; they have the computer programming expertise to modify the ACES software, but they lacked the operational expertise to design the campaign planning logic.

Research Objectives

Given this general problem formulation, the research team focused on several specific objectives. In developing a capability for flexible time step simulation, the essential problem was to devise a method by which players can enter force directions for more than one day of battle. To address this problem, the research team defined two objectives: (1) develop a methodology by which players can translate general operational objectives into specific rules for force employment and (2) define decision criteria such that the simulation actions and results remain within reasonable, practicable bounds. In developing more realistic naval force actions, the single research objective focused on selecting relevant weapon systems, describing their operational characteristics, and defining rules for their employment. In addition to these explicit objectives, the research team focused on supporting user educational objectives and developing model changes consistent with current United States (US) military doctrine.

Scope

This research addresses the functional design of the ACES model, but it does not include any software programming, guidelines, or protocols. The logic requirements provide a blueprint for detailed computer programming work. To ensure the feasibility and practicality of proposed logic changes, the research team conducted the project in close coordination with AFWI personnel. In short, the research represents a proposed change to existing computer software; the capability and cost to implement that change represent real bounds on the scope of this work.

Chapter 2

Literature Review

Purpose

To provide a framework for developing technical changes to the ACES wargame model, this literature review addresses four preliminary areas of inquiry. First, it defines basic terms that delineate the model's purpose and subject matter. The review then identifies distinguishing characteristics of educational wargame models, and from these characteristics, specifies criteria by which proposed changes to the ACES model may be evaluated. Finally, the chapter surveys current educational wargame models to examine their methods of time simulation. This literature review provides the conceptual context in which improvements to the ACES model must be viewed.

Definitions

ACES is a computer-assisted wargame model used to support education in campaign planning at the operational level of war. Before proceeding with any analysis, the terms in this description must be defined. The *Department of Defense Dictionary of Military and Associated Terms* defines a wargame as "a simulation, by whatever means, of a military operation involving two or more opposing forces, using rules, data, and procedures to depict an actual or assumed real life situation."[4] As with many wargames today, ACES uses a computer model to simulate the combat environment in which players act. Based on player input, the model's logical and mathematical representations portray the status and results of play. Such computer model representations depend critically on a structured set of rules within which player decisions must be made.[5]

The subject matter of the ACES wargame model is the *operational level of war*. Current US military doctrine defines the *operational level of war* as "employing military forces in a theater of war or theater of operations to obtain an advantage over the enemy and thereby obtain strategic military goals through the design, organization, and conduct of campaigns and major operations."[6] Department of Defense (DoD) policy directs the emphasis of intermediate and senior service schools to be the operational level of war and its planning activities.[7]

The human skills necessary to conduct these activities are referred to as *operational art*, and this art emphasizes both the qualitative and quantitative aspects of war.[8] The medium for exercising operational art and planning the operational level of war is the campaign plan.[9] Campaign plans inherently coordinate joint and combined forces: "Campaigns of the US Armed Forces are joint; they serve as the *unifying focus* for our conduct of warfare."[10] As operational art is a central focus of theater commands, intermediate and senior PME schools emphasize these skills in their curricula, and the ACES wargame model seeks to support their educational goals.

Today, wargames and simulations have spread to virtually every segment of education.[11] Education is instruction for the purpose of intellectual development and the cultivation of intuition and judgment.[12] Such intuition or judgment can be thought of as "the reasoning forward from what is already known."[13] Education must be distinguished from training, which is oriented more toward particular skills or technical proficiency.

Education tends toward broader objectives and emphasizes individual thought processes, rather than a uniformity of problem solution.[14] "People become educated, as against trained, insofar as they achieve a grasp of critical principles and an ability to choose, organize and shape their own ideas and living beliefs by means of them."[15]

Despite education's focus on general reasoning processes, the subject matter context remains important. General knowledge and problem-solving about a subject cannot be completely abstracted from its specifics.[16] This has important implications for the design of instructional models. As an educational wargame model, ACES must represent the nature of operational level warfare and provide students experience with the thought processes inherent in operational art.

Characteristics of Educational Wargame Models

Model Taxonomy. The Military Operations Research Society (MORS) has developed a comprehensive taxonomy of wargame models,[17] and the DoD now uses this classification in its *Catalog of Wargaming and Military Simulation Models.*[18] The taxonomy distinguishes models primarily according to their differing purposes; it classifies models as *analytic* or *education/training*. The object of an analytical model is to examine the nature of something, and thus, the purpose emphasizes the real accuracy of model outputs or results. To accomplish this purpose, analytical models typically provide high resolution (highly detailed) representations of environmental factors.[19] In contrast, education/training models convey concepts, principles, and tenets; they usually focus on the decision processes of model input.[20] The education/training model outcomes must be plausible, as students must be able to see the cause and effect relationships in their actions.

As ACES is an education/training model, its emphasis rests with the reasoning and decisions that go into the wargame play, and these activities must reflect desired learning objectives.[21]

Learning Objectives and Design. Clearly, the objective of a wargame must be the deciding factor in a model's structure; designers must provide models that fulfill user objectives.[22] For training and education models, learning objectives provide the basis for design. In training, players should gain proficiency in a wartime task, and hence there is an emphasis on replicating actual procedures used in operations. The detail required should reflect the detail normally encountered in conducting the task. In an educational model, the narrow task focus expands to conceptual development and reasoning processes.[23] As an educational model, ACES exercises principles and concepts taught at intermediate and senior service schools. The *ACES Player Handbook* lists the ACES learning objectives:[24]

1. Comprehend the command and staff relationships involved in the operation of a unified command conducting a joint exercise.
2. Apply US/Allied military doctrine in a theater warfare exercise.
3. Apply the principles of war in a theater warfare exercise.
4. Comprehend how logistics factors impact the support and sustainment of forces engaged in combat operations.
5. Comprehend how the Air Force's roles and missions support a joint/combined
6. theater commander's campaign plan.
7. Value the complexity of the decision-making process for employment of air
8. and space power to include logistics, intelligence, and political factors.

To support such learning objectives, a wargame model must represent the general operational environment, but many details of environmental status and procedures can be omitted. Complexity of data input, model execution, and output can actually detract from a model's utility in an educational setting.[25] Generally, both input and output data can be more aggregated, and detail resolution can be larger in these wargames.[26] This simplification allows educational goals to surface above the detail.

With an emphasis on education, design changes to the ACES wargame model should focus on the student's input processes. In their work, *Wargaming and Its Uses*, Peter Perla and Raymond Barrett summarized the design considerations for operational level wargames used in education:

> Designing a game requires comprehensive and coherent study and modeling of the interplay of different types of forces, carrying out different kinds of missions, for different sorts of reasons. Successful translation of quantitative and qualitative tactical analysis into an accurate and meaningful game requires a basic understanding of how players interact as they develop different approaches to the problems posed by the game. Finally, it requires an ability to translate that understanding into intelligible and practical procedures so that players can concentrate on making decisions, not on remembering rules.[27]

Thus, a focus on student reasoning processes must clearly take precedence. The need to *simulate reality* must be balanced against the needs of the educational process. Concern for training or analytic realism can actually reduce the educational value of the wargame. In order to educate students in operational art, a wargame must abbreviate elements normally considered part of realism.

In addition to focusing on student learning objectives, several other characteristics distinguish educational wargame models. First, school curricula structures require that a number of independent games be played simultaneously. Since sufficient computer support personnel are typically not readily available, the models must be user friendly.[28] That is, the model's input design must be simple and readily learned. School curricula structures also limit the time devoted to the wargame; typically, three to five days can be used for most educational wargames.[29] To support such timing constraints, the ratio of game time to real time represents a critical consideration. In the educational setting, it is usually desirable to set this ratio relatively high. Over a few days of play, an operational level wargame should be capable of simulating at least 30 to 40 days of conflict in order to meet the learning objectives.[30] The exploration of issues such as mobilization, strategic lift, campaign phasing, measures of effectiveness, and sustainment requires that the players come to appreciate how their decisions impact longer term results. The ACT research seeks to provide this capability in the ACES wargame model.

Educational Model Criteria

Three issues commonly arise in the evaluation of wargame models: (1) scope, (2) flexibility, and (3) efficiency.[31] *Scope* refers to a wargame's replication of appropriate units, systems, and functions. The decision of appropriateness relates directly to the game's purpose; in short, the detail required depends on the game's objectives. The second issue, *flexibility*, refers to the game's ability to be used in a number of situations and to accommodate a variety of users. However, as the focus of purpose and use increases, the importance of *flexibility* decreases. The third issue, *efficiency*, addresses the resources that must be expended to exercise the game, both by managers and users. In this regard, time is viewed as a critical resource for all.

Educational Objectives. From these general modeling issues and the characteristics of educational wargames, the research team identified several criteria for evaluating proposed changes to the ACES model. First, the changes should be evaluated on how well they represent the higher level mental processes required in operational art.[32] This criterion can be viewed as the need to support the game's educational objectives.

The focus on educational objectives provides the fundamental consideration in developing changes; it guides the scope of functions represented by the model and balances the needs for operational realism and educational utility.

Simplicity. Closely related to the focus on educational objectives, the need for simplicity serves as a second criterion. To emphasize student conceptual processes rather than the details of game play, user rules and input procedures should be relatively simple. The campaign planning process must be translated into logical operations that aggregate realistic detail, while preserving the conceptual integrity of the exercise. Simplicity of rules and procedures should permit students to focus on the game's educational objectives.

Flexibility. As the educational subject matter is *operational art*, student thought processes will likely vary in framing solutions to planning problems. Indeed, developing solution approaches is central to the educational objectives. Thus, the model framework should be *flexible* enough to allow alternate approaches to planning. Such flexibility is typically incorporated by either free-form data entry, or sets of alternative planning options.[33] The model should not provide a single, closed-form course of action for the students.

Practicability. Beyond basic educational attributes, proposed changes to the ACES model must also be practicable. Logic changes must be incorporated into the model software with reasonable design and programming efforts. In addition, the revised game must be executed under the same resource constraints as currently apply. Support requirements during wargame play must especially be maintained at current levels.[34] This criterion represents a practical constraint on solution approaches and possibly, on the achievement of the other criteria. Table 1 summarizes the criteria for proposed changes to the ACES model.

Table 1. ACES Model Change Criteria

Criterion	Description
Educational Objectives	Supports educational objectives for operational level of war and campaign planning.
Simplicity	Game rules and input procedures are easily understood and readily executed.
Flexibility	Permits alternate approaches to campaign planning and different reasoning processes.
Practicability	Consequent software changes must be feasible, and wargame support requirements must not be increased.

Operational Level Wargame Model Review

Before considering technical changes to the ACES model, the research team examined other operational level warfare models for methods of time simulation. The team believed these models could provide ideas or methods applicable to the ACES modifications. The current DoD inventory of wargaming and military simulation models lists 355 manual and computer based models.[35] Of these, only five directly support the education of operational level warfare with joint force representations. One of these models, the RAND Strategy Assessment System (RSAS), has recently undergone major revision and is now called the Joint Integrated Contingency Model (JICM). Table 2 lists these models and their primary users.

Table 2. Operational Level Education Wargame Models

Model	Primary Users
Air Warfare Simulation (AWS)	HQ USAFE Warrior Preparation Center
Ground Warfare Simulation (GRWSIM)	HQ USAFE Warrior Preparation Center
Joint Armed Forces Staff College Warfare Simulation (JAWS)	National Defense University Armed Forces Staff College
RAND Strategy Assessment System (RSAS) Joint Integrated Contingency Model (JICM)	National Defense University Naval Post Graduate School Naval War College
Joint Theater Level Simulation	Joint Warfare Center National Defense University Army War College

Source: *Catalog of Wargaming and Military Simulation Models*. Joint Chiefs of Staff.

While these models differ significantly in their detail, most of them allow processes and events to occur at a controller-specified ratio of exercise time to real clock time; the games may be conducted at speeds equal to or faster than real clock time.
This time compression is achieved simply by accelerating the rate of play. The players provide input orders, and events occur automatically according to predetermined computer algorithms. The Joint Armed Forces Staff College Warfare Simulation (JAWS) serves as an example of this mode of time simulation. JAWS is a computer wargame model that the Armed Forces Staff College has used in its exercises since 1982. The model simulates air, land, and sea force actions. In the normal course of training, the exercise simulates about 12 days of battle.[36]

A notable exception to this continuous method of time simulation is JICM. The RAND Corporation designed JICM as an analytical tool, but it now supports a number of wargame exercises at the senior service schools. JICM differs from the other models in that it presents warfighting from a *strategic-operational* perspective, rather than the *operational-tactical* perspective. Combat adjudication is highly aggregated, but includes many parameters affecting theater-level combat that are only implicitly considered in operational-tactical models.[37] JICM also allows *compressed* play in incremental time steps. While the game can operate with twelve hour, four hour, or six minute intervals, the model can execute multiple-cycle iterations based on user campaign input.[38]

JICM air operations illustrate the model's operational focus and incremental time simulation. Individual aircraft packages are not simulated individually, but are treated as *levels of effort* within a combat adjudication cycle.[39] The level of effort is specified by apportioning percentages of air assets to various air missions and allocating air assets within these missions to a prioritized list of targets and objectives. Players determine the timing of attacks by specifying the percentage of mission effort to be flown during each of the six four-hour periods of the day. With this guidance on apportionment, allocation, and mission timing, the simulation generates air tasking orders for each four hour block of combat adjudication. Player participation can be included after this four hour cycle, or the system can be run in an automatic mode relying on a scripted decision log that makes relevant force decisions.

This type of aggregated decision modeling and execution serves as the best example for possible changes to the ACES model. With its emphasis on strategic and operational issues, JICM provides a model for adapting incremental time steps to accelerated game play. Its focus on general force mission areas is similar to the current ACES model, and thus, JICM provides a relevant source of ideas for developing ACT for ACES. However, extreme technical dissimilarities between the two models preclude any direct application of the JICM procedures to ACES. JICM merely provides a conceptual motivation for changes to the ACES model.

Summary

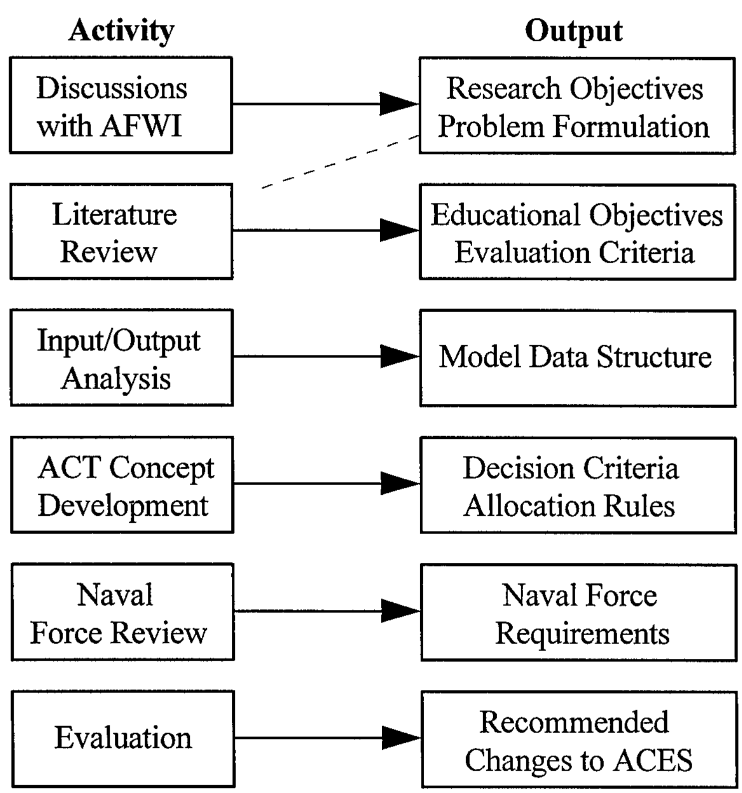
This literature review provided several key insights for the ACES ACT research. First, the review identified the ACES wargame learning objectives as the central focus for changes to the model. Second, it clarified the distinguishing characteristics of educational wargame models and provided criteria to guide the development of changes to the ACES model. Finally, the review identified JICM as a model from which to draw ideas for the needed changes to ACES. From this foundation, a structured analysis of technical changes to the ACES model could proceed.

Chapter 3

Methodology

Structured Approach

To develop changes to the ACES wargame model, the research team followed a logical, structured approach. This approach incorporated both analytical and creative activities in a disciplined research process. Figure 1 outlines that process, identifying the major research activities, their output, and the logical relations between the efforts. The research proceeded as planned through these sequential activities.



Initial Discussions. The research process began in initial discussions with the AFWI personnel who manage the ACES model. These discussions covered the model's purpose, structure, and limitations. This preliminary work also included *hands-on* familiarization with the ACES model. The project's problem formulation, research objectives, and methodology evolved from these initial investigations.

Literature Review. To refine understanding of the issues involved in designing an educational wargame model, the research continued by reviewing relevant literature. As previously discussed, the topics for review included the major dimensions of the project's subject matter: wargame models, education theory, and military doctrine for the operational level of war. This review provided several important products. First, it clarified and emphasized the ACES model's educational objectives. Second, it identified criteria for use in evaluating prospective model changes. Finally, the literature review provided some ideas from which to approach the model's technical problems. These insights laid the groundwork for detailed model analysis.

Input/Output Analysis. Changes to the ACES model depend critically on the model's current technical structure and capabilities. To establish a baseline, the research team conducted a detailed analysis of the model's current input and output data. This analysis focused on the user's view of model information. The resulting data structure provided the framework in which changes to the model could be made.

Proposed Changes and Evaluation. Based on the model data structure and operations, the research team developed specific changes to incorporate variable time step simulation and realistic naval force representations. The proposed changes include the logic for the ACT modification (allocation rules and decision criteria) and naval force requirements for the model. Structured analysis, brainstorming, and discussion generated the proposed changes. The team evaluated the proposed changes using the criteria defined in the literature review. This evaluation, conducted largely in discussions with AFWI personnel, provided feedback for several iterations of change. The final iteration concluded with the team's recommended changes to the ACES wargame model.

The ACES Framework

In focusing the research efforts, the ACES wargame model's current structure served as the starting point. Figure 2 depicts the model's general functional scheme. In short, the model takes user campaign input, translates it to a form useable by adjudication algorithms, executes those algorithms, and provides output to the player. To incorporate a variable time step simulation capability and more realistic naval play, the research efforts focused on the campaign input and translator functions.

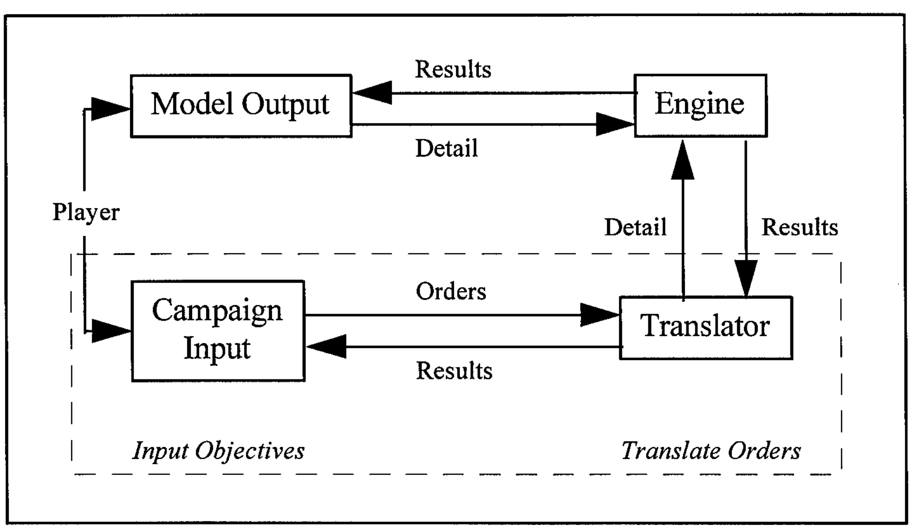


Figure 2. ACES Functional Design

The research focused on these functions for two reasons. First, the campaign input function represents much of the educational content of the wargame. The student planning process and decision input are central to their learning experience. Second, the ability of the computer to translate their input into executable algorithms enables the simulation to provide consequent feedback to students, thus completing the game's cause and effect cycle. The student view of campaign planning and the translation of that view into executable computer code provided the functional context for the research process.

Results Format

This project's research results had to be presented in a very structured format. As the results represent recommended changes to the ACES model, they must readily facilitate software programming. For changes to the model's naval system play, this requirement translated to a list of weapon systems, their characteristics, and rules for employment. For changes to the model's time step simulation, the recommended changes assumed a more complicated form.

The essential factor in redesigning the model's time step simulation was the ability to represent changes in a set of conditional logic rules. That is, the results had to be presented in a series of *if-then-else* statements. Decision trees organized these statements into the necessary conditional logic. This format, referred to as *branch and sequel decision trees*, provided the structured medium by which to recommend changes to the ACES model. The *branch and sequel decision trees* serve as blueprints to translate operational requirements into a computer programming language, and the first step in defining these requirements was to analyze the model's current data structure.

Chapter 4

Model Input/Output Analysis

Analysis Design

To establish the current structure and operation of the ACES model, this chapter analyzes the model's current input/output data structure. The analysis focuses on the player's view of data, relating available information (output) to decisions the players make (input). The data description follows the game's three phases: (1) planning, (2) sortie allocation, and (3) ground order input. Describing the data structure in this manner provides a framework in which to identify desired changes in the model.

The analysis details generic information types contained in the ACES model. The research team extracted this information from system documentation.[40] The current model includes three different scenario data bases: (1) Southwest Asia (ACES Phoenix), (2) the Korean Peninsula (ACES Dragon), and (3) a notional scenario (ACES Pegasus). This generic data type description applies to all three versions.

Planning Phase

Players begin the ACES game in a planning phase. During this phase, players beddown aircraft, assign roles to these aircraft, and build sustainability plans. Players also assign national intelligence assets to specific areas of interest to acquire information on the enemy. Figure 3 outlines the information and decision data requirements for the current ACES planning phase.

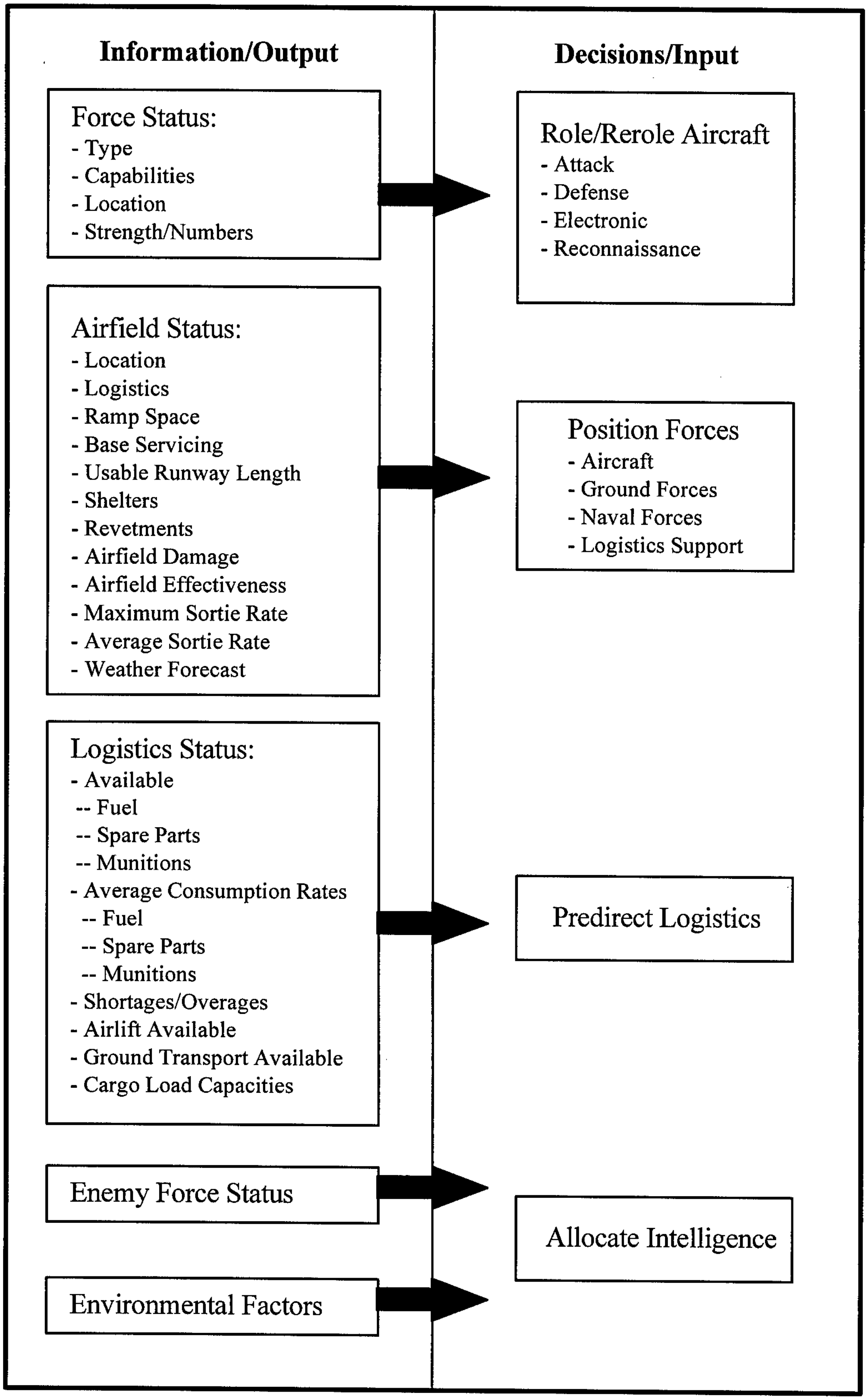


Figure 3. Planning Phase Data

The ACES model provides planning information in a set of reports. The *Friendly Air Order of Battle* and *Friendly Land Order of Battle* reports provide force status, while the *Friendly Basing/Cross Servicing Plan* provides airfield status. The *Friendly Logistics Status* and *Friendly Logistics Shortfalls* reports identify the logistics status of friendly airfields. Comparable reports provide enemy force status and environmental data. In addition to the reports, planning information resides on *SUN SPARCSTATION* screenmap displays and the *PC* graphical user interface (GUI) used for model inputs.

During this planning phase, players decide aircraft role assignments and locations. In addition, they move logistics resources to support the forces and *predirect* resupply of these resources. The final step in this phase is the tasking of national intelligence assets. The game divides the theater into different zones; players assign point values to these zones to indicate the relative weight of effort in each. Collected intelligence produces more highly reliable information in the player's output reports. With the intelligence priorities established, players move to the next phase of the game.

Sortie Allocation Phase

Player actions continue with the sortie allocation phase. In this phase, players apply air assets to meet their planning objectives. The central focus in this effort is the construction of an integrated tasking order (ITO). In assigning specific missions to aircraft, the ITO represents the game's orders for 24 hours of air operations. This effort depends on work accomplished during the planning phase and on more detailed air force status information. Figure 4 outlines the information and decision data requirements for the ACES sortie allocation phase.

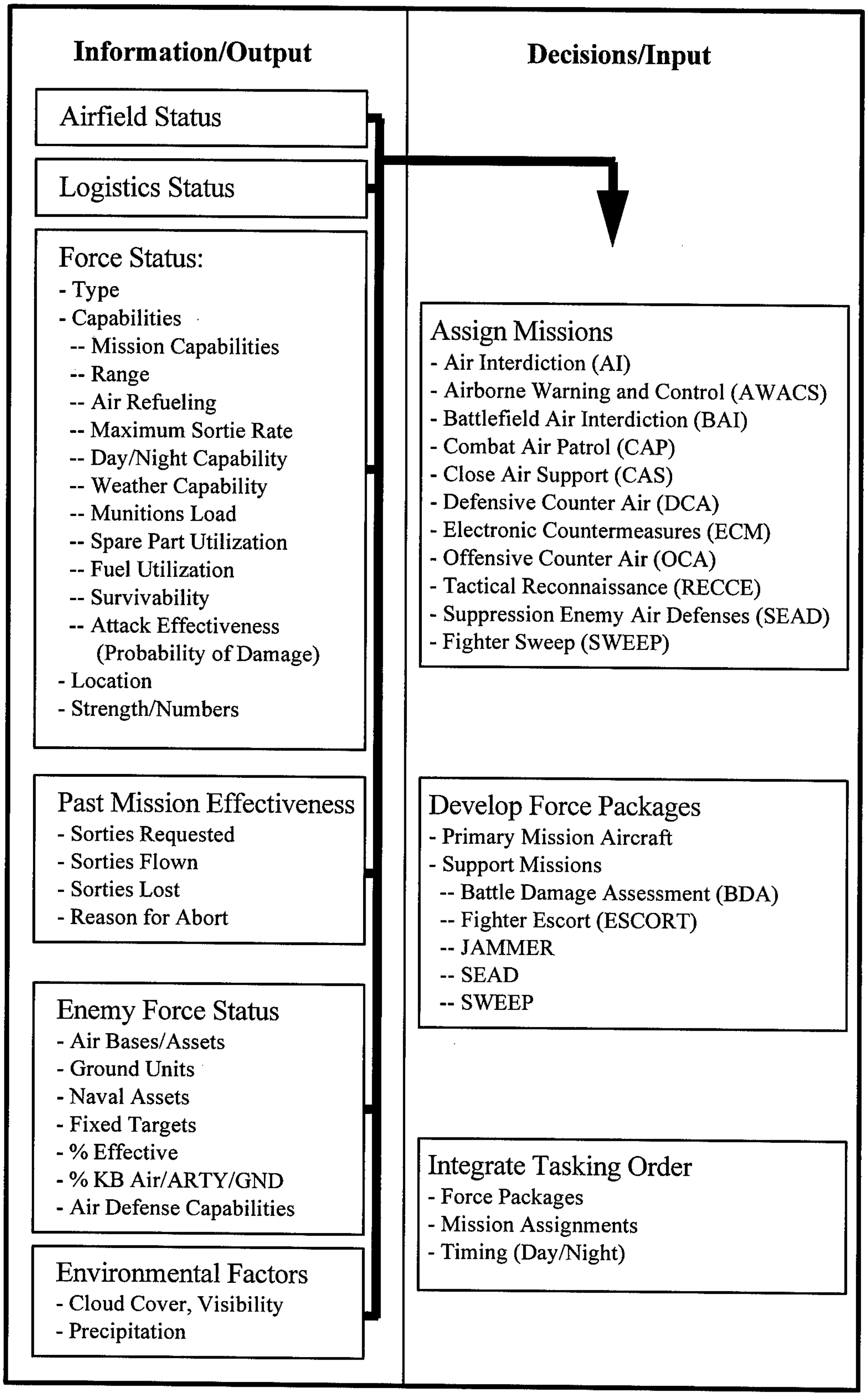


Figure 4. Sortie Allocation Phase Data

The process of building the ITO centers on the assignment of air missions. ACES models 11 primary air missions and 5 support missions; the *ACES Players Handbook* describes these missions in detail.[41] Players formalize the mission assignments by building a force package for each specific mission assignment. Package development requires detailed information on logistics, force status, enemy activity, and weather. Players spend a great deal of time analyzing the tactical situation and constructing these force packages. The ITO represents the culmination of this detailed planning process.

The information analysis required to develop the ITO represents the most complex activity in the game. In addition to the reports used in the planning phase, players reference a collection of other reports for friendly and enemy status: *Air Order of Battle*, *Aircraft Loss Summary*, *Sortie Summary*, *Sorties Remaining*, *Mission Summary*, *Mission Input*, and *Target Status*. Much of the data in these references are duplicative, and players must sort through the formatted reports for critical information. Figure 4 presents all the relevant decision data types.

Ground Order Phase

Comparable to the sortie allocation phase for air assets, the ground order phase develops 24 hours of instructions for ground units. The phase depends critically on information developed in the planning phase, and it should be conducted in close coordination with sortie allocation activities. In this phase, players control the movement and employment of all land units. The game simulates six types of land units and three types of ground orders. Figure 5 outlines the information and decision data requirements for the ACES ground order phase.

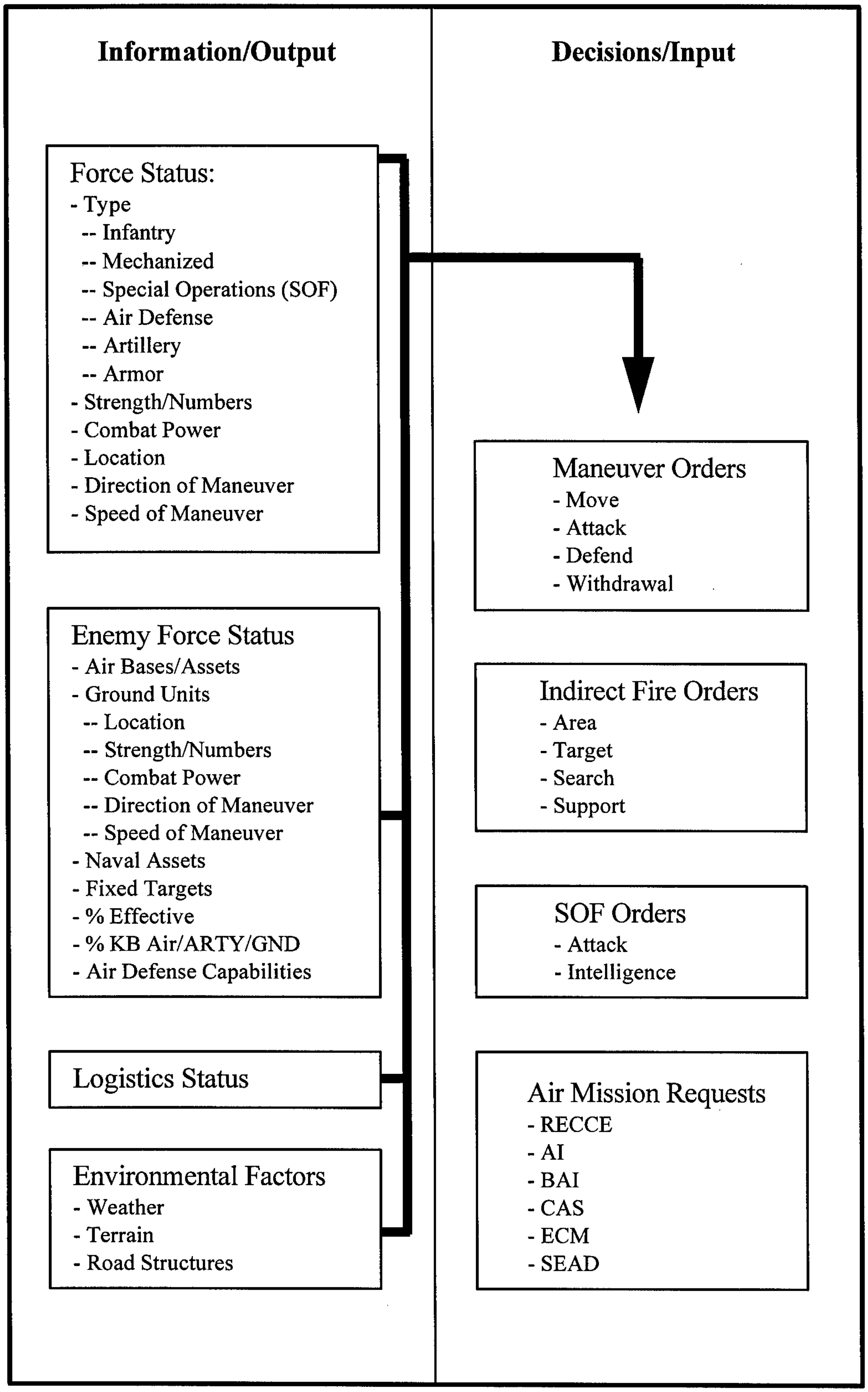


Figure 5. Ground Order Phase Data

Land players must work closely with intelligence sources to identify the major enemy forces, their location, strength, movement, and combat power. Using this information, players direct their own forces through maneuver, fire, and SOF orders. The players specify orders for the day and night cycle; units not given specific orders default to a purely defensive posture. Players must also integrate air and ground actions. The land players must develop a prioritized list of air mission requests that support ground objectives.

Friendly and enemy ground force information resides in a small set of reports: *Land Order of Battle, Land Units Destroyed, Land Summary, and SOF Operations Mission Inputs*. Reports from the planning and sortie allocation phases also provide relevant information. Figure 5 identifies all the key decision data elements.

Naval Force Data

Despite detailed modeling in the land and air components, the current ACES model presents only a rudimentary depiction of naval forces. The game simulates generic, stationary aircraft carriers that serve merely as floating airfields; there is no representation of other naval capabilities or missions. This deficiency in naval force data, a central concern of this research, is addressed in Chapter 6 of this report. Thus, analysis of the model's land and air decision data provided the basis of recommendations for ACT modification to ACES.

Chapter 5

Advanced Combat Timeline (ACT) Recommendations

Introduction

As previously explained, the current ACES wargame executes play in 24 hour increments. Players analyze each day's results, then design and input orders for the next 24 hour period. This process limits the game to one day of war for each day of real time and virtually precludes playing a campaign longer than a few days. The ACT modification will resolve this problem by providing ACES the capability to take larger time steps, steps as large as 30 days. ACES will thus be able to execute a three month campaign in three to five days of game play. The new capability will provide students a more effective learning environment in which to exercise the operational level of war.

To enable the ACT concept to function, two significant programming changes must be made. First, a set of decision criteria must be developed to provide players the ability to communicate their warfighting objectives to the computer through a series of *if/then* statements. These statements will provide the logical *branches and sequels* envisioned by the players, allowing the ACES wargame to make decisions about the prosecution of the campaign consistent with the players objectives. The second necessary program change requires the design of force allocation rules. These rules will provide the basic method of order input for the air, ground, and naval forces. The following sections recommend the types of decision criteria and allocation procedures to be incorporated in the ACES family of wargames.

Model Decision Criteria

Ground Forces. In reviewing current army doctrine and the model's ground order input/output data, the research team identified *unit combat strength* and *maneuver orders* as central to planning ground force actions in ACES.[42] Thus, the recommended ground order decision criteria focus on three options: (1) stopping the game turn completely, (2) changing the axis of an attack, or (3) switching to a new strategy. A few examples will illustrate these notions. If an unexpected enemy breakthrough occurs, the players will likely want the game turn to end so they develop a new strategy to deal with the unexpected occurrence. For such a situation, an adequate set of branches and sequels is too complex for the players to design in advance. The game will simply stop at this point, allowing players to assess the situation and develop a new strategy.

In the case of a friendly attack, the players will input desired branches and sequels such as: "Have infantry division *X* attack until it sustains 5% casualties, then have infantry division *Y* pass through division *X* and assume the attack." A change in strategy would look like: "Attack north along the east coast of North Korea until reaching hex 35-41 (Kuum Ni), then adopt a defensive posture for 48 hours. Following this 48 hour operational pause, resume the attack northwest toward hex 32-43 (Wonson)."

The ultimate goal is to allow the computer to make transitions for the players without having to stop the entire simulation and wait for another lengthy input. Figure 6 and Figure 7 identify decision criteria based upon ground casualties and terrain objectives. The figures do not include every possible criterion, but they do provide adequate criteria to address the common ground decisions encountered in the ACES wargame.

Input Ground Force Criteria

1. If __________% of __________ Corps has been destroyed, then . . .
2. If __________% of __________ enemy Corps has been destroyed, then . . .
3. If __________% of __________ Division has been destroyed, then . . .
4. If __________% of __________ enemy Division has been destroyed, then . . .
5. If __________% of __________ friendly ground artillery has been destroyed, then . . .
6. If __________% of __________ enemy ground artillery has been destroyed, then . . .
7. If __________% of __________ friendly AAA/SAM units are destroyed, then . . .
8. If __________% of __________ enemy AAA/SAM units are destroyed, then . . .
9. Combinations of the above.

Examples:

If 10% of 1st Cav Division has been destroyed, then stop attacking and adopt a defensive posture.

If 50% of enemy AAA/SAM units are destroyed, then switch to unescorted aircraft packages.

Figure 6. Ground Force Criteria

Input Terrain Criteria

1. When friendly forces reach ____ degrees north, then . . .
2. When enemy forces reach ____ degrees north, then . . .
3. When friendly forces capture Pyongyang, then . . .
4. When enemy forces capture Seoul, then . . .
5. If a friendly attack fails to advance at least _____ hex/es in _____ hours, then . . .
6. If an enemy attack fails to advance at least _____ hex/es in _____ hours, then . . .
7. If a friendly attack advances faster than _____ hex/es in _____ hours, then . . .
8. If an enemy attack advances faster than _____ hex/es in _____ hours, then . . .
9. Combinations of the above.

Examples:

When 1st Cav Division reaches Kuum Ni, pause the attack 24 hours and then resume the attack northeast toward Wonson.

If an enemy attack fails to advance at least one hex in any 48-hour period, switch the air allocation percentages to option 2 (heavy strategic target emphasis).

Figure 7. Terrain Criteria

Air Forces. With the ACES wargame focus on air campaign planning, airpower application is the most critical element in successful prosecution of the exercise. As described in the model data analysis, aircraft mission assignments represent the primary task in directing air force assets, and this focus is entirely consistent with current air campaign planning procedures.[43] Given this emphasis, Figure 8 recommends air force decision criteria that concentrate on air mission assignments. Again, these criteria are intended to either stop the simulation, or to instruct the simulation to transition to another course of action already specified by the players.

Input Air Force Decision Criteria

1. If _____% of friendly CAS sorties are destroyed/damaged in ____ hours, then . . .
2. If _____% of friendly BAI sorties are destroyed/damaged in ____ hours, then . . .
3. If _____% of friendly AI sorties are destroyed/damaged in ____ hours, then . . .
4. If _____% of friendly OCA sorties are destroyed/damaged in ____ hours, then . . .
5. If _____% of friendly DCA sorties are destroyed/damaged in ____ hours, then . . .
6. If _____% of friendly AWACS sorties are destroyed/damaged in ____ hours, then . . .
7. If _____% of friendly SWEEP sorties are destroyed/damaged in ____ hours, then . . .
8. If _____% of friendly ECM sorties are destroyed/damaged in ____ hours, then . . .
9. If _____% of friendly BDA sorties are destroyed/damaged in ____ hours, then . . .
10. If _____% of friendly CAP sorties are destroyed/damaged in ____ hours, then . . .

11-20. Repeat 1-10 for enemy sorties.

21. If _____ number/percentage of (friendly aircraft type) are destroyed in ____ hours, then . . .
22. If _____ number/percentage of (enemy aircraft type) are destroyed in ____ hours, then . . .
23. If no/few enemy sorties are detected airborne in _____ hours, then . . .
24. Combinations of the above.

Examples:

If 7% of friendly CAS sorties are destroyed in any 24-hour period, then switch to heavier SEAD escort packages.

If 5 or more F117s are destroyed in any 24-hour period, then stop the turn (so we can plan a new strategy).

Figure 8. Air Force Decision Criteria

Naval Forces. Naval play is an evolving capability in the ACES wargame, and naval force decision criteria must be incorporated in ACT. Naval force issues tend to differ from ground or air concerns. Damage to a major fleet unit will likely cause the command authority to consider a change of tactics. For this reason, damage or destruction of individual ships represents an important criterion for which the players must decide alternative actions. As an example, damage to an aircraft carrier (CV/CVN) may inhibit its ability to launch and recover aircraft, and this will likely cause the fleet to withdraw from the threatened area. In other instances, the enemy threat may dictate actions. A CVBG will likely avoid areas where the enemy has a significant submarine threat, but once that threat is neutralized, the carriers will operate in the area. Given these considerations, Figure 9 identifies recommended decision criteria for naval forces.

Input Naval Force Decision Criteria

1. If a CV/CVN is destroyed, then . . .
2. If a CV/CVN is _____% damaged, then . . .
3. If a CG is destroyed, then . . .
4. If a CG is _____% damaged, then . . .
5. If a SSN is destroyed, then . . .
6. If a SSN is _____% damaged, then . . .
7. If an ARG is destroyed, then . . .
8. If an ARG is _____% damaged, then . . .
9. If ____% of a carrier airwing is destroyed/damaged, then . . .

10 - 18. Same as above for enemy units.

19. Combinations of the above.

Examples:

If any carrier is damaged, then withdraw all carriers 100 miles from enemy coastline.

If all enemy submarines off the eastern coast of Korea are destroyed, then move both CVBGs into that area.

Figure 9. Naval Force Decision Criteria

Surface-to-Surface Missile (SSM) Systems. In addition to traditional conventional forces, ACES should model SSM systems. These systems include such current delivery platforms as Scuds, No Dongs, and TLAMs. In Desert Storm, the Scud threat was the most difficult targeting problem facing coalition forces, and the SSM threat has grown since that war. These systems will likely remain a serious problem in future conflicts as more nations develop SSM systems and the ability to launch advanced weapons. Based on these prospects, ACES must model this threat, and ACT must incorporate decision criteria for SSMs. Figure 10 outlines such SSM criteria.

Input SSM Decision Criteria

1. If _____ enemy SSM launches occur in _____ hours, then . . .
2. If _____% of SSM launchers are destroyed, then . . .
3. If chemical weapons are employed by enemy SSMs, then . . .
4. If biological weapons are employed by enemy SSMs, then . . .
5. If nuclear weapons are employed by enemy SSMs, then . . .
6. Combinations of the above.

Examples:

If zero enemy SSM launches occur in any 24-hour period, then stop the SSM suppression campaign and switch to a strategic bombing campaign against POL and electrical power generation targets.

If enemy SSMs employ chemical/biological/or nuclear weapons, stop the turn and allow us to develop an appropriate response.

Figure 10. SSM Decision Criteria

Strategic Targets. In addition to enemy forces, ACES simulates many types of enemy strategic targets: (1) leadership; (2) command, control, communications and intelligence (C3I); (3) military industry (MID); (4) electronic warfare (EW); (5) nuclear, biological, and chemical (NBC) production; (6) petroleum, oil, and lubricants (POL); (7) transportation; and (8) port facilities. To integrate attacks against these strategic targets into the players' plans, decision criteria must be developed. Figure 11 recommends criteria based on desired target damage levels. Such damage level objectives reflect realistic targeting practices. It must be noted that the criteria do not include transportation targets. For these targets, the game provides inherent engineering capabilities to accomplish bridge repair and replacement. Also, the game automatically reroutes ground units around any destroyed bridges or junctions. Thus, there is no requirement for additional computer code to address transportation target damage.

Decision Criteria Summary. In addition to the scenario-based decision criteria, several other capabilities must be incorporated into ACES ACT. First, players must be able to specify the number of battle days to be run if other stopping criteria do not terminate the simulation. This capability will allow players to control the simulation's time increments. In addition, new report formats must record the simulation chronology and highlight the execution of player decision logic. Such reports will allow players to trace the model's operation and identify the reasons behind the model's results.

With a wargame as complex as ACES, it is impossible for the computer program to address every contingency . The decision criteria established in this research will provide ACES an extensive capability to adapt to player objectives and decision making. As the ACES family of wargames evolves, new capabilities will likely require additional decision criteria. The criteria specified here provide a strong baseline capability for the ACES model to simulate the significant air, land, sea, and strategic issues of a modern theater campaign over an extended period of time.

Input Strategic Target Decision Criteria

1. If ________ % of Enemy Leadership targets are destroyed, then . . .
2. If Enemy Leadership target numbers _______ are _______% destroyed, then . . .
3. If ________ % of Enemy C3I targets are destroyed, then . . .
4. If Enemy C3I target numbers _______ are _______% destroyed, then . . .
5. If ________% of Enemy MID targets are destroyed, then . . .
6. If Enemy MID target numbers _______ are _______% destroyed, then . . .
7. If ________% of Enemy Electricity targets are destroyed, then . . .
8. If Enemy Electricity target numbers _______ are _______% destroyed, then . . .
9. If ________% of Enemy EW targets are destroyed, then . . .
10. If Enemy EW target numbers _______ are _______% destroyed, then . . .
11. If ________% of Enemy Chem Prod targets are destroyed, then . . .
12. If Enemy Chem Prod target numbers _______ are _______% destroyed, then . . .
13. If ________% of Enemy Chem Stor targets are destroyed, then . . .
14. If Enemy Chem Stor target numbers _______ are _______% destroyed, then . . .
15. If ________% of Enemy Nuc Prod targets are destroyed, then . . .
16. If Enemy Nuc Prod target numbers _______ are _______% destroyed, then . . .
17. If ________% of Enemy Nuc Stor targets are destroyed, then . . .
18. If Enemy Nuc Stor target numbers _______ are _______% destroyed, then . . .
19. If ________% of Enemy POL Prod targets are destroyed, then . . .
20. If Enemy POL Prod target numbers _______ are _______% destroyed, then . . .
21. If ________% of Enemy POL Stor targets are destroyed, then . . .
22. If Enemy POL Stor target numbers _______ are _______% destroyed, then . . .
23. If ________% of Enemy Ports targets are destroyed, then . . .
24. If Enemy Ports _______ are _______% destroyed, then . . .
25. If ________% of Enemy Bio Prod targets are destroyed, then . . .
26. If Enemy Bio Prod target numbers _______ are _______% destroyed, then . . .
27. If ________% of Enemy Bio Stor targets are destroyed, then . . .
28. If Enemy Bio Stor target numbers _______ are _______% destroyed, then . . .
29. If ________% of Enemy RR Yard targets are destroyed, then . . .
30. If Enemy RR Yard target numbers _______ are _______% destroyed, then . . .

31-60. Same as 1-30 except for friendly targets.

61. Combinations of the above.

Examples:

If Enemy Leadership target numbers 001, 002, 003, 004, and 005 are 85% destroyed, then stop bombing leadership targets and begin bombing POL targets.

If 50% of Friendly Ports are destroyed, then stop the turn (so we can plan a new defense strategy).

Figure 11. Strategic Target Decision Criteria

Sortie Allocation Rules

Having established the necessary decision criteria, the research had to develop recommendations for a new sortie allocation process. ACES currently requires players to build all air packages for each 24 hour period. The players allocate each package to a specific target for the coming turn until all targets are attacked, or until they run out of aircraft. In other words, they spend several hours designing and targeting their aircraft packages. This sortie allocation process is neither feasible, nor desirable for ACT. The players have no way of predicting what aircraft losses will occur, nor can they reliably predict the degree of damage that will be inflicted on any given targets. Additionally, ACES incorporates the fog and friction of war; targets can be obscured by weather, weapons and aircraft can malfunction, or pilots can simply miss the target. For these reasons, ACES requires a mechanism to prioritize targets and aircraft packages.

Players will likely have different ideas about target priorities and optimal aircraft employment. This greatly complicates game programming. The simplest solution from a programmer's perspective would be to construct a hierarchy of default packages which allows the computer to select the *best* aircraft for a given mission. The players would merely input a prioritized target list, and the computer would select the aircraft. Other existing simulations, such as *JLASS*, use this method.[44] However, players typically complain about computer-determined force applications.[45] ACT will alleviate this problem by allowing the players to set both target and aircraft package priorities. Players will establish the percentage of sorties to assign to each mission and the percentage of sorties to fly day and night. Figure 12 illustrates the allocation rules.

Allocate Sortie Assignments

Day/Night Sortie Allocation: 45% Day/55% Night

Mission Allocations: 25% DCA
25% BAI
25% OCA
10% SEAD
10% AI
5% AWACS

Figure 12. Air Allocation Example 1

Based on these allocations, ACES ACT will calculate the number of sorties that can be allocated to each mission each day. It will recalculate at the beginning of each day to account for any combat losses or damaged aircraft. Also, the decision criteria specified in the previous section could be used to instruct ACES to make a transition to a new allocation percentage. As an example of such a transition, Figure 13 shows a transition from the air superiority emphasis in Figure 12 to an interdiction priority.

Allocate Sortie Assignments

If no enemy sorties were detected in the last 24 hours, then change sortie allocations to the following:

Day/Night Sortie Allocation: 50% Day/50% Night

Mission Allocations: 5% DCA
35% BAI
5% OCA
10% SEAD
40% AI
5% AWACS

Figure 13. Air Allocation Example 2

This methodology represents another way players could provide *branches and sequels* to ACES; it will allow ACES to make the transition to a new air strategy without having to stop and wait for another input from the players. The example in Figure 13 represents a transition from achieving air superiority to a strategic targeting campaign, and it is merely one example of transitions between mission priorities.

Once players allocate the percentage of sorties, they will then construct a prioritized airframe list. This list is designed to allow the players to choose the types of aircraft that will be used to perform each mission. Selection formats will allow students to identify airframe types in a descending order of preference for each mission area. Figure 14 illustrates the mission assignment format.

Allocate Airframe Mission Assignments

AWACS	AI	BAI	CAS	DCA	OCA
E3	F117	F18	A10	F15	F15E
E2	B2	F16	AV8	F14	B1pkg
	B1	A10	F18	F16	B1
	F15E	AV8	F16	F18	B2
	B52	F15E	A37	F4	B52pkg

ECM/JAM	CAP	SEAD	SWEEP	BDA	ESCORT
EA6B	F15	F4G	F15	F5	F15
EF111	F14	F18	F14	F14	F14
	F16	F16	F16	F16	F16
	F18	F5	F18	F4	F18

Figure 14. Sample Airframe Allocation Format

In this example, the first airframe with which the computer would fill a CAS mission would be an A10. If insufficient A10s are available, the program would select

AV8s, F18s, F16s or A37s in priority order. The more choices the players identify, the sooner the computer will be able to service the target. Unserviced targets will be retained for the next 24 hours of combat.

The OCA entries in Figure 14 illustrate the issue of escort packages. The first choice is F15Es, the second and third choices are both B1s. The first B1 choice (B1pkg) contains escort and suppression aircraft, whereas the second B1 choice contains little or no escort and suppression aircraft. This example illustrates how ACT will allow the players to flexibly create packages for attacking varied targets in varying conditions. In the example, B1s may fly with heavy escort for the first few days, until a decision criterion on air superiority is met, then it may transition to unescorted packaging for the remainder of the war.

With the priority table input, the simulation will calculate the total number of sorties available for the next day, and based upon that total number, it will allocate airframes. The players will also build strike packages for each of the airframes listed above. Assigning different names to the packages will allow the computer to distinguish packages the players want.

Once players complete the aircraft assignment selection criteria, they must build target lists. Players must develop a target list for each mission type and distinguish the targets for day and night attack. This day and night distinction merely provides players flexibility in determining when the targets will be attacked; targets could be assigned to day, night, or both day and night attack as desired. Figure 15 illustrates the targeting priority format.

Prioritize Target Assignments

AWACS	AI	BAI	CAS	DCA	OCA
DAY:					
SK1	LDR001	1NKARMBD	1ROKCORP	SK1	SUNAN
SK2	LDR002	2NKARMBD	2ROKCORP	SK2	WONSAN
SK3	LDR003	3NKARMBD	3ROKCORP	SK3	KUUM NI
SK4	LDR004	4NKARMBD	4ROKCORP	SK4	KACHN
SK5	LDR005	5NKARMBD	5ROKCORP	SK5	MIRIM
SK6	LDR006	22NKINFDIV	6ROKCORP	SK6	YONGDAM
NIGHT:					
SK1	NUC001	3NKINFDV	3ROKCORP	SK1	KUUMNI
SK2	NUC002	4NKINFDV	4ROKCORP	SK2	YONGDAM
SK3	NUC003	5NKINFDIV	1ROKCORP	SK3	SUNAN
SK4	CHM001	6NKINFDIV	2ROKCORP	SK4	KACHN
SK5	CHM002	7NKINFDIV	5ROKCORP	SK5	MIRIM
SK6	CHM003	1NKARMBD	6ROKCORP	SK6	WONSON

ECM/JAM	CAP	SEAD	SWEEP	BDA	SSMs
DAY:					
NK4	27-32	AAAxxx	NK4	35-41	NONE
NK5	26-28	SAMMID1	NK5	32-43	
NK6	25-30	SAMMID2	NK6	24-48	
NK1	25-33	SAMHI1	NK1	21-45	
NK2	4-19	SAMHI2	NK2	22-43	
NK3	50-31	SAMHI3	NK3	21-40	
NIGHT:					
NK4	26-33	SAMHI4	NK4	34-40	SEOUL
NK5	25-34	SAMHI5	NK5	27-38	PUSAN
NK6	27-35	SAMHI6	NK6	26-38	KIMPO
NK1	29-36	SAMHI7	NK1	22-38	OSAN
NK2	31-35	SAMHI8	NK2	16-39	SUWON
NK3	33-36	SAMHI9	NK3	24-50	KUNSON

Figure 15. Target Prioritization Format

Once players have prioritized the targets, the program will start with the first target on each list and begin allocating aircraft until it expends all the sorties available for that cycle (day or night). Any targets that cannot be attacked or damaged to the level specified by the player will remain on the list for the next 24 hour period. These targets will remain in the queue until they are destroyed or damaged to the players desired level. If an AI, BAI, or OCA target list is exhausted, the game turn will end, and the players will be required to implement a new priority and strategy. All other mission types will reaccomplish the original target priority lists until a decision criteria directs the computer to a new strategy.

At the end of the first 24 hour period, the computer will perform several calculations. It will determine the number of sorties available for the next 24 hours based upon losses, damaged aircraft, and destroyed/damaged/captured air bases. It will check the intelligence reports on all targets, determining if sufficient damage has occurred, or if they need to remain on the target priority list for the coming turn. It will also check the established decision criteria to evaluate if any have been triggered which require the turn to end or a new strategy to be implemented. If no change has occurred, it will begin the next 24-hour attack cycle. If a decision criterion has been triggered, the model will implement the new designated strategy and begin the next 24-hour attack cycle with the new allocation percentages. Of course, if no targets remain for attack, the simulation will stop.

The computer will save all previous player input tables anytime a decision criterion is triggered. Players could easily edit the saved data tables, allowing them to correct the decision criterion that was triggered with minimal effort. If they desire to input an entirely new strategy, they would have that option as well. This process will allow the game to be played in multi-day increments, providing the players an opportunity to see their strategy executed over the course of an entire campaign.

Ground Allocation Orders

The ground orders portion of ACES will also require significant modifications for ACT. The current input screens are insufficient for ACT for two main reasons. The first has to do with the concept of *massing*. The current ACES wargame does not restrict the massing of ground forces within a single hex; in other words, players could move literally dozens of divisions into the same 16 kilometer wide hex, and they would function with minimal impairment. This represents an unrealistic condition and a serious limitation of the model. Many units in one hex area would not have room to deploy and fight, and they would be far more vulnerable to air and artillery attack. This problem would manifest itself quite prominently in ACT. Second and third echelon forces moving toward the front would likely move faster than the units actually engaged in combat; at some point, these second and third echelon units would *catch up* with the lead units, at which point they too would find themselves in combat and slowed down. It is conceivable that the entire offensive would eventually be concentrated within very few hexes along the front.

The second major problem deals with ground attrition rates. During ACES testing, programmers discovered that ground forces in Korea had absolutely no hope of breaking through the US and Republic of South Korean (ROK) defenders in the two to three days of warfare the game was covering. They modified the program to increase the lethality of attacking units, which resulted in the ability of the attackers to create breakthroughs. This created a situation where it was necessary to devote large amounts of CAS and BAI sorties if the US/ROK forces wanted to stop the offensive. Although attrition was perhaps too high, ACES now created a dilemma for the US/ROK players (within the time constraints of the game) emphasizing the need for air support to contain/stop the North Korean offensive. Unless these attrition rates are lowered to more realistic levels, the first game turn might see the total destruction of one or both armies. The other potential problem with these high attrition rates is that they will trigger the stopping criteria after every single 24-hour turn. If the players have set 10% damage to any division as a decision criteria, this will likely occur every single 24-hour period.

To alleviate these problems, three measures must be taken. First, programmers must readjust the game's force attrition rates. Second, they should activate the *massing function* inherent in the current model. This function restricts massing and inflicts significant movement, combat power, and vulnerability penalties on units that *overstack.* Third, the programmers must activate the C*orps Orders* capability. ACES contains a segment of inactive code that was designed to allow the game to be played by corps instead of divisions and brigades. This *Corps Orders* capability will be most appropriate for ACT, allowing the players to input simple, high-level orders for attack, defense, movement, and withdrawal. The players would also have the ability to specify intermediate objectives or routes of march, but the execution of these orders could be turned over to the computer. ACES actually evolved as an Army model to which the air play was added; therefore, it contains a rather robust ground combat model which should prove more than adequate for ACSC purposes. The decision criteria presented for ground units must also be related to the model to allow the incorporation of the players' *branch and sequel* plans. Players could easily input ground orders using the current point and click GUI with only minor modifications.

Naval Force and SSM Orders

Due to the pace of naval operations, an ACT capability is mandatory. Many naval operations, especially those involving surface ships, require several days to execute. For example, an amphibious invasion takes several days for the ships to reach the desired landing site, neutralize the defenses, and land the forces. An antisubmarine warfare campaign can take days or weeks to sanitize an operating area. The current ACES format accommodates carrier operations and TLAM strikes, and these operations will work in ACT under the logic guidelines established for the air forces. Surface ship operations can be input using the current GUI, and the program will move the ships to their destinations. Thus, there should be no extensive program modifications to include naval force orders in ACT.

In addition, SSM operations do not present any programming difficulties for ACT. SSMs can be executed using a target priority list attached to the target prioritization format (see Figure 15). Ground movement will be handled through the ground order phase using the GUI. These measures are simple, logical extensions of the recommended ACT methodology. Thus, the ACT recommendations incorporate all the major force elements represented in ACES into a flexible time step simulation capability.

Chapter 6

Naval Play Recommendations

Introduction

This chapter recommends changes to the existing ACES data base to improve the model's naval force simulation capabilities. Recognizing deficiencies in the current game, the AFWI and ACSC staffs have initiated efforts to improve the model's naval capabilities. The recommendations proposed here support and augment those efforts, identifying additional changes to integrate naval play and improve the educational utility of the ACES wargame model.

Maneuvering Carrier Capability

The first recommended change is to build a viable, capable, and maneuverable carrier battle group (CVBG). Initial design should incorporate a hex to hex move capability that players initialize at the beginning of each game day. As the ACT modification will permit multiple-day play, the carrier will then require defined *zones* in which to maneuver. These zones should incorporate relatively precise latitudes and longitudes, with maneuvering zones of varying radii. The game's naval component commander should be given the flexibility of establishing both the area and the size of his desired maneuver zones.

Although aircraft carriers are capable of speeds greater than 30 knots, realistic speeds of advance (SOA) should limit the carrier to no more than 18 knots. The computer should restrict CVBG movement to 27 hexes, or 432 miles (24 hours x 18 knots maximum per hour) during any 24 hour game period. This will effectively simulate the inherent maneuvering limitations imposed by launching and recovering aircraft, turning into the wind to conduct flight operations, and other SOA limitations imposed by operating in a tactical naval environment.

The task force should also have the capability to maneuver in any hex that contains an ocean component. In addition to defining a realistic *brown water* advance capability, this will allow players to move forces around and between identifiable land masses, thus providing the flexibility of using enroute islands, bays, and geographic features for optimal tactical advantage. Although carriers typically operate one hundred nautical miles or more from an enemy's shoreline, there are scenarios that require the CVBG to operate in closely confined waters. Routine operations conducted within the restricted confines of the Persian Gulf, the Norwegian fjords, and the Greek islands provide examples of such operations. Thus, ACES should provide players the opportunity to maneuver the CVBG through such varied scenarios and tactical situations.

Carrier Air Wing Development

The carrier air wing provides theater commanders a variety of power projection and crisis response options.[46] The ACES Dragon and Phoenix models currently include notional air wings largely consistent with actual US deployment loadouts, but some specific changes will upgrade the model's realism. Table 3 summarizes the recommended air wing composition. Although ACES Pegasus portrays a mythical realm, a realistic naval arm will enhance the scenario's educational value in the practice of operational art. In this regard, the blue forces should be identified as a western nation with uniquely identifiable western assets. Likewise, the red forces should be constructed primarily of Russian assets and capabilities. These changes will provide more substantive naval play for ACES Pegasus.

Table 3. Recommended ACES Air Wing Composition

Current	Proposed
44-46 F/A-18 Hornets	36 F/A-18 Hornets
14 F-14D Tomcats	14 F-14D Tomcats
4 A-6E Intruders	4 E-2C Hawkeyes
4 EA-6B Prowlers	5 EA-6B Prowlers

Source: *Employment of Navy and Marines Forces*, Air University Publication 16 (20).

Aircraft. To simplify the naval environment, the recommended changes ignore many of the support aircraft that currently accompany a carrier air wing on deployment. By 1999, the S-3B Viking antisubmarine warfare aircraft and the A-6E Intruder bomber will be retired from carrier air wing service. In addition, helicopter and electronic support aircraft operations, while critical to the CVBG, are beyond the current ACES objectives. For completeness, these assets could be included in the game without detailed performance parameters, remaining largely *invisible* to the players.

For the represented carrier aircraft, roles and capabilities must be refined to ensure realistic mission assignments. The F/A-18 Hornet (designated F18A/D in ACES) is the future of the Navy's fighter and attack corps. Accordingly, the aircraft performs the following missions defined by the ACES model: AI, BAI, CAP, CAS, DCA, OCA, SEAD, and SWEEP. In addition, Hornets can perform the package support missions that include ECM/JAM, ESCORT, SEAD, and SWEEP.

The E-2C Hawkeye (E2E in ACES) is the naval version of the Air Force AWACS. It provides the over-the-horizon command and control for the fleet and will be employed to perform the AWACS mission. Due to a lack of inflight refueling capability, the E-2C has an on-station time of approximately three and one half hours, compared to approximately twelve hours for the Air Force AWACS.[47] The E-2C is typically the first aircraft to be launched off of the ship and the last to be brought aboard at the end of the flying day.

The F-14D Tomcat (ACES designation F14A/D) has been the primary anti-air asset of the Navy and will continue to fulfill that mission well into the 21st century.[48] Within the past two years the Tomcat has been given the added capability of delivering ground ordnance and will assume an increased role in the strike attack mission as the A-6 Intruder fleet is retired. ACES will provide the F-14D with the capability of performing both air-to-air and air-to-ground missions. As such, Tomcat missions should include: AI, BAI, CAP, CAS, DCA, OCA, and SWEEP. In addition to these mission capabilities, a deployed Tomcat squadron will typically have two aircraft configured with tactical reconnaissance mission pods. Therefore, F-14Ds in ACES should also be provided the ability to be tasked for RECCE and BDA missions. The reconnaissance aircraft will typically be spotted on the flight deck such that one is always airborne and the other is preparing to launch and relieve the aircraft on station. Therefore, ACES will provide players with a naval tactical reconnaissance asset on every event. Package support missions for the Tomcat will include: ECM/JAM, SEAD, ESCORT and SWEEP.

The EA-6B Prowler (designated EA6E) provides jamming and anti-missile system services to the fleet and ground commander. The Prowler is capable of performing ECM and SEAD missions.[49] ACES currently uses the EA-6B and the EF-111 Raven (EF111E) in these two roles, but the US Air Force has considered retiring all of the active EF-111 squadrons and utilizing Navy EA-6Bs in their place. Navy aircrew and aircraft will deploy ashore with Air Force assets to perform this mission. In the event the Air Force decides to forego it's fleet of EF-111s, ACES should reflect this change and replace any EF-111s with the EA-6Bs. The Navy will likely provide four squadrons for this mission, with a typical squadron containing five aircraft. Table 4 summarizes the recommended mission assignments for all the carrier aircraft.

Table 4. Recommended Aircraft Mission Assignments

	Aircraft				
Mission	F14A/D	F18A/D	E2E	EA6E	AV8A
AWACS			P		
AI	P	P			P
BAI	P	P			P
CAP	P	P			
CAS	P	P			P
DCA	P	P			
ECM/JAM	S	S		P,S	
ESCORT	S	S			
OCA	P	P			P
RECCE/BDA	P,S				
SEAD	S	P		P,S	S
SWEEP	P,S	P,S			

Note: "P" denotes primary mission, "S" denotes support mission.

Sortie Generation. The number of sorties that can be generated by the carrier air wing is another area that requires modification. While a typical carrier air wing flies around 120 sorties on an average day, this number is low for the ACES program. An actual carrier generates those 120 sorties employing approximately half (40-45) of the embarked aircraft. ACES utilizes all aircraft and does not consider maintenance or other down-time factors. Therefore, given 59 aircraft for use, the actual number of sorties available would be much higher than 120. Naval aircraft typically operate on one and one half hour operating cycles, recovering, refueling, and relaunching at the same interval throughout the day. While one group of aircraft is airborne, the other has just landed and will be going through turnaround and preflight preparation for relaunch. This level of detail does not need to be placed into the program, but the player should have a maximum number of 59 sorties available for tasking before battle losses accrue.

Beyond the basic mission areas modeled in ACES, the P-3C Orion provides antisubmarine mission capabilities. Land-based and capable of both submarine and surface search capabilities, the P-3C offers a tremendous capability to sanitize and patrol large areas of the sea.[50] Employing the Harpoon antiship missile and antisubmarine torpedoes, the Orion is capable of providing it's own offensive power. With the additional ability to downlink large volumes of tracking and parametric data, the Orion also provides the battle group with a tremendous over-the-horizon targeting capability. Although not capable of aerial refueling, the P-3C's airborne time averages ten to twelve hours per mission. ACES should incorporate two to three squadrons of Orions, with eight aircraft per squadron, and provide them with the capability of engaging submarine and surface ship contacts.

Carrier Battle Group Development

Integral to a properly defined naval environment are the assets and capabilities that accompany a carrier and its air wing to a theater of operations. The current game has no capability beyond the aforementioned air assets to counter airborne threats. In order to develop a realistic naval environment, a notional CVBG must be developed that accurately represents the capabilities and threats expected to be encountered in the defined theater of operations.

In this regard, the game should model simulated platforms that accompany the carrier in its maneuvers. The ultimate goal of the programmers will be to allow the player the option of separating surface and subsurface units into individual elements that are capable of operating either in conjunction with the carrier, or independently, as the situation warrants. This capability, placed on both red and blue sides, will allow players the capability of simulating realistic naval engagements.

Surface Combatants. At a minimum, the recommended CVBG should consist of two *Ticonderoga* class cruisers (CG-47 Aegis class), one *Spruance* class destroyer (DD-963 class), one *Arleigh Burke* class destroyer (DDG-51 class), two *Oliver Hazard Perry* class frigates (FFG-7 class), and two *Los Angeles* class attack submarines (SSN-688 class).[51] Mine countermeasures and logistics capabilities must also be provided. Game programmers will need to incorporate the specific capabilities of each class of ship into the model, allowing the player to employ the available assets as the situation warrants.

Cruisers are large vessels primarily utilized in the anti-air warfare role. Accordingly, they are outfitted with an allotment of surface-to-air missiles that can typically reach out to approximately 81 nautical miles. Cruisers typically operate in concert with the aircraft carrier, providing the fleet with critical air protection.[52]

Destroyers are a smaller class of vessel that can be dual-roled. *Arleigh Burke* class destroyers are outfitted with weapons that allow them to fulfill both the anti-air and antisubmarine warfare missions. Also, with the capability of firing the Tomahawk cruise missile, the *Arleigh Burke* class provides a capable and flexible platform.[53] The *Spruance* class destroyer is primarily committed to antisubmarine duties, but with the capabilities of firing Harpoon antisurface and Sea Sparrow air defense missiles, the destroyer also provides flexibility and synergy to the battle force.[54] *The Oliver Hazard Perry* class frigate is the latest frigate class added to the fleet. Used primarily for escort of amphibious forces and underway replenishment forces, it is fully capable of engaging in anti-air, antisurface, and antisubmarine activities.[55]

Submarines. In addition to the aforementioned surface forces, the game will offer the capability of employing the stealthy *Los Angeles* class attack submarine. Utilized primarily in the attack role, *Los Angeles* submarines are capable of subsurface, surface, and overland attacks, utilizing a mix of torpedoes, Harpoon, and Tomahawk missiles. The submarines should be programmed to operate either in conjunction with the carrier task force, or in independent missions.[56] All of these platforms, although capable of greater speeds, should be limited to a maximum SOA of 18 knots per hour. This again reflects tactical speed limitations and simulates a realistic average speed.

Missiles. As part of the strategic attack capabilities, the game will provide a finite and realistic number of both Tomahawk Land Attack Missiles (TLAM) and Tomahawk Anti-Ship Missiles (TASM). TLAM provides a key element in the battle group's power projection with a range of nearly one thousand miles.[57] TLAM and TASM capable ships currently include the *Ticonderoga*, *Burke*, *Spruance*, and *Los Angeles* class platforms. The specific number of cruise missiles available depends on the mix of TLAM capable platforms available in the region. Players will select TLAM targets, and the program will execute launches until it exhausts the missile supply. Execution should be limited to launches against strategic targets; this precludes unrealistic use against maneuvering ground or sea surface units. Due to real design limitations on the capacity of the Vertical Launch System, a ship depleted of missiles will need to return to an established friendly port before a resupply of TLAMs can be effected. Currently, most naval vessels are capable of carrying a mix of approximately 60 missiles, while the *Aegis* class cruisers are capable of 122. Players should be afforded the opportunity, before play begins, of loading whatever mix of TLAM or anti-air missiles they decide appropriate for the situation. This feature, combined with the requirement to return to port for reload, will add realistic limitations on the team's employment of TLAM and TASM missiles.

Surface ships will also be outfitted with a suite of surface-to-surface and surface-to-air missiles. Programmers can easily program weapon system characteristics into each unique platform, allowing for automatic shot selection at inbound enemy aircraft. Automatic shot selection is desired in order to enhance compatibility with the ACT requirements and current employment criteria.

Surface-to-air engagements will typically employ the SM-2 Extended Range Block IV missile. The SM-2 is the middle ring of protection for the CVBG, with FA-18s and F-14s providing the outer ring.[58] The SM-2 system is currently being retrofitted with a new threat upgrade (NTU) system to improve its capability and reliability.[59] ACES should incorporate the advanced system to ensure a realistic and viable defense system representative of future capabilities.

Miscellaneous Capabilities. Surface ships with artillery capabilities will also be available for player use. Players should be able to designate land targets that are candidates for naval bombardment as either independent operations, or in support of amphibious landings. This feature will obviously be limited to the operational range of the guns, yet it will provide the player with accurate, all-weather fire support that is responsive to the theater commander in the planning and execution of various scenarios.[60]

All of the aforementioned surface units will also have the use of a SH-60B helicopter. This provides surface ships with the same surface and subsurface capabilities that the carrier air wing employs in its aircraft loadout. Programming should include a provision that will automatically incorporate a SH-60B track within 50 miles of the host platform position. This allows for the realistic capabilities that an over-the-horizon shooter brings with it into the theater of operations.

The two *Los Angeles* class submarines that will be incorporated offer the player the ability to penetrate undetected into enemy territory and to provide superb fleet defense for all surface units. Armed with both the Harpoon antiship and TLAM missiles, these platforms provide additional strike and offensive capabilities to the battle commander.

As previously mentioned, ACES should also provide a capability to counter a formidable mine threat. Despite their relative simplicity, naval mines are responsible for sinking more ships per dollar expended than any other weapon system in existence.[61] Accordingly, the players will have mine countermeasures ships (MCM class) and mine hunting coastal patrol craft (MHC class) with which to counter the mine problem.

Logistics Considerations

Logistics factors must be programmed into the naval portion in much the same manner that they currently exist in the air and ground modules. Through prepositioned helicopter and fleet surface assets, navy ships at sea are extremely sustainable. Players will manage fuel and ammunition requisitions in the logistics section of the program, with appropriate naval assets and requirements listed. Logistics support in the current model occurs instantaneously. Programmers can either continue this practice, or attempt to simulate normal supply timelines in fleet operations.

The carrier will require aviation fuel approximately every three to five days. Normal capacity is well above that, but standard practice ensures that the ship is maintained at its fullest and most operational state possible. With a nuclear fuel plant, the power plant portion of most carriers will not require support from logistics assets. Ammunition resupply will take place as it does for the air forces. Players will order the expected requirements, and the ammunition will arrive on the ship at a designated time.

In addition, all other surface forces will require refueling support. This support can be accomplished with the fueling cycle of the carrier. Although fleet oilers make their deliveries on a continuous cycle, ACES could incorporate a simpler model that merely tops off the fleet every few days.

As previously mentioned in the section on TLAM development, a friendly port must be identified to allow the TLAM/TASM equipped ships the ability to retire to a safe haven for rearmament. These ports should be located close to the theater of operations (Japan for instance, in ACES Dragon), allowing the players the option of retiring the platforms to reload.

Marine Amphibious Forces

In addition to the CVBG, an independent Marine amphibious force should be incorporated that will include at least one amphibious assault ship (*Tarawa* class LHA), one amphibious transport dock (LPD), two landing dock ships (*Whidbey Island* class LSD), and two escort destroyers of either the *Arleigh Burke* or *Spruance* classes. The LHA should be outfitted with eight AV-8 Harriers (designated AV8A) and thirty helicopters. In addition, the LHA should be capable of transport and delivery of up to 1,800 combat troops.[62]

The Harrier is designated AV-8A. Although the AV-8 is technically a dual-role aircraft, the aircraft is not typically flown in an air-to-air role. The aircraft should be capable of flying the AI, BAI, CAS, OCA and SEAD missions. AV-8 aircraft will constitute a portion of the naval air arm, and as such, they will be available to the air component commander for tasking. However, their primary use will be in conjunction with Marine amphibious force movements. The helicopters will again be an *invisible* asset that is programmed into the game, allowing for aerial assault and troop insertion.

In order to maintain a simple, yet capable force, the actual composition of the recommended surface forces does not include the entire collection of assets in a real-world naval environment. However, the recommended forces do provide the important surface, subsurface, and Marine amphibious fleet units, providing the ACES family of games with an effective naval capability.

Enemy Naval Forces

Having provided the player with sufficient and well-defined *blue* assets, it is also important to provide realistic opposition (*red*) forces. The three different model scenarios require the addition of theater specific threats. Without providing the actual force components desired, this discussion addresses the minimum capabilities that must be incorporated.

In ACES Pegasus, the threat should reflect an extremely capable and formidable naval threat. As such, the surface and amphibious forces should be built to the same level as that of the blue forces. Although the presence of a *Nimitz* type carrier on both sides is unrealistic, it would provide both sides with a somewhat equal and balanced initial capability. Programming simplicity and economies of effort for the AFWI staff is added if both navies are provided with essentially the same generic outfitting and definition.

In ACES Dragon, the naval threat will be modeled around the capabilities of the North Korean Navy. North Korea maintains a coastal naval force, composed primarily of fast attack gunboats, missile ships, and amphibious support ships.[63] These assets have a relatively limited range (500 to 800 miles) and should not be provided any strong logistical or at-sea refueling capability. In addition, North Korea possesses a fleet of approximately twenty *Romeo* class diesel submarines and fifty midget submarines that provide a surface attack capability. North Korea's submarine fleet does not currently possess any antisubmarine capability.[64]

Naval surface combatants are outfitted with relatively antiquated Russian style systems that date technologically back to the 1950s and 1960s. Therefore, programming should provide them with very limited offensive capabilities. Their mining and amphibious capabilities are more advanced and should provide the North Korean players with an extensive mine laying capacity.[65] North Korea maintains a fleet of one hundred or more hovercraft and amphibious assault ships that can deliver ashore thirty-five to fifty-five combat troops apiece.[66] This number is relatively small by western naval standards, but when combined in a total force, the red player will have the capability to deliver nearly 5,500 troops into an amphibious assault zone.

In ACES Phoenix, the naval order of battle will be constructed from naval assets prevalent in the Persian Gulf region. Iran and Iraq retain the most prominent naval force structures in the area. Because of the small size and relatively shallow nature of the Gulf, a brown water navy is typical of the assets found in the region. The Iraqi Navy includes multiple small coastal gun and missile boats, and missile technologies programmed for the Iraqis will be representative of Russian and French systems.[67] Iraq does not maintain any subsurface capability.

Iran, on the other hand, has been quietly building the largest and most respected navy in the region. The Iranian Navy now contains a multitude of naval vessels, including corvettes, frigates, and a growing fleet of *Kilo* class submarines.[68] In addition, Iran maintains a very large and capable coastal patrol, manned primarily by forces of the Iranian Revolutionary Guard.[69] These boats are extremely difficult to detect and have the capability to pose a significant threat to any naval vessel in the region. Thus, ACES must model a viable naval capability in the Gulf region.

Summary Considerations

This chapter has recommended changes to provide more effective naval simulation capabilities in all three versions of ACES. In addition to these changes, AFWI programmers will need to adapt the naval portion of the model to the recommended ACT modifications. The programmers have indicated that the modifications and their integration are practicable. The changes will provide a strong beginning for naval play and will facilitate further evolution of the ACES model in serving the needs of joint force education.

Chapter 7

Conclusions

This research project developed the logic requirements and software design criteria necessary to incorporate flexible time step simulation and realistic naval force actions into the ACES wargame model. The recommended modifications allow players maximum control over the use of simulated forces and the prioritization of targets throughout an extended period of game play. The modifications also incorporate new naval force representations to facilitate more realistic naval simulation. These changes will provide players a greatly increased capability to explore joint force campaigns in the time allotted by educational curricula.

In evaluating the recommended changes, the criteria identified in the research literature review provide a frame of reference. The preeminent criterion is to support the model's educational objectives. In this regard, ACT for ACES will challenge the higher level mental processes required for operational art; players will have to analyze and anticipate the long-term consequences of their decisions. This longer term focus improves the game's operational level orientation and represents the primary benefit of the ACT modifications. In addition, the more realistic naval play will greatly enhance the model's ability to simulate joint forces, improving the game's focus on joint force learning objectives.

To further support the wargame's educational objectives, the research team specifically designed the model upgrades to be simple. The decision criteria, allocation rules, and input procedures are logical, direct, and uncomplicated. This simplicity moves ACES game play away from tactical details, toward the broader concepts of campaign planning. The changes will allow students to rise above technical details of the computer and its scenario to focus on the skills of operational art.

Despite the model's simplicity, its methodology provides flexibility in responding to different student thought processes. The *branches and sequels* format facilitates different planning approaches and integrates alternative courses of action into an adaptive planning process. The methodology allows students to envision and plan for multiple contingencies with different solution approaches. With this inherent flexibility, ACT for ACES will provoke thought and provide practice in operational art.

To become a reality, the ACT modifications must also be practicable. The best measure of this criterion is the judgment of the AFWI programmers. Discussions with those programmers indicate that the recommended modifications pose no special programming problems or support requirements. The conditional logic and screen display inputs provide a feasible, practical design for changes. Therefore, the ACT modifications will be incorporated in a new version of the ACES wargame model.

In summary, this research project sought to improve the educational utility of the ACES wargame model by providing it a flexible time step simulation capability and more realistic naval force representations. In providing logic requirements and design criteria, the project allows AFWI programmers to incorporate these capabilities into the ACES model to provide an educational wargame that better reflects the concepts and issues of campaign planning at the operational level of war.

Endnotes

1. Joint Chiefs of Staff, *Joint Modeling and Simulation Strategy* (Washington: The Joint Staff Deputy Director for Technical Operations, May 1993), i.

2. Air Force Wargaming Institute, *ACES Player Handbook* (Maxwell Air Force Base, AL: Air University College of Aerospace Doctrine, Research, and Education, April 1994), 1.

3. Ibid., 2.

4. Joint Chiefs of Staff, *Dictionary of Military and Associated Terms,* Joint Publication 1-02 (Washington: US Government Printing Office, 23 March 1994), 409.

5. Peter P. Perla, *The Art of Wargaming* (Annapolis, MD: United States Naval Institute, 1990), 172-177.

6. Department of the Air Force, *Basic Aerospace Doctrine of the United States Air Force*, Air Force Manual 1-1, Volume II (Washington: HQ USAF, March 1992), 46.

7. Joint Chiefs of Staff, *Military Education Policy*, Chairman's Memorandum 344-90 (Washington: The Joint Staff Deputy Director for Manpower and Personnel, 14 April 1990), 3.

8. Headquarters Department of the Army, *Operations*, Field Manual 100-5 (Fort Monroe, VA: US Army Training and Doctrine Command, June 1993), 6-2.

9. Joint Chiefs of Staff, *Dictionary of Military and Associated Terms*, 60.

10. Joint Chiefs of Staff, *Joint Warfare of the US Armed Forces*, Joint Publication 1 (Washington: US Government Printing Office, 11 November 1991), 45.

11. Sarane S. Boocock and E.O. Schild, *Simulation Games in Learning* (Beverly Hills, CA: Sage Publications, 1988), 6.

12. John W. Masland and Laurence Radway, *Soldiers and Scholars* (Princeton, NJ: Princeton University Press, 1977), 50.

13. Robert Glaser, "Education and Thinking: The Role of Knowledge, *American Psychologist* (February 1984), 64-70.

14. Ernest R. Hilgard and Gordon H. Bower, *Theories of Learning* (New York: Appleton Century Craft, 1986), 542.

15. Elena M. DeCosta, "Metacognition and Higher Order Thinking: An Interdisciplinarian Approach to Critical Thinking in the Humanities," *Thinking Across the Disciplines, the Proceedings of the Annual Conference of the International Society for Individualized Instruction*, October 1986, 14-15.

16. D. N. Perkins and Gavriel Salomon, "Are Cognitive Skills Context Bound?," *Educational Researcher* (January-February 1989), 17-24.

17. Lowell B. Anderson and John H. Cushman, *A Taxonomy for Warfare Simulation* (Alexandria, VA: Military Operations Research Society, October 1989).

18. Joint Chiefs of Staff, *Catalog of Wargaming and Military Simulation Models* (Washington: Government Printing Office, March 1994), Appendices 1-9.

19. James Dunnigan, *The Complete Wargames Handbook* (Revised Edition) (New York: Quill William Morrow, 1992), 236-237.

20. Colonel Michael E. Heenan, *Educational Wargaming* (Maxwell Air Force Base, AL: Air Force Wargaming Institute, January 1992), 1.

21. Air Force Wargaming Institute, *ACES Player Handbook*, 1.

22. Peter P. Perla, "A Guide to Navy Wargaming," *Wargaming Anthology*, Ed. Center for Naval Warfare Studies (Newport, RI: US Naval War College, 1991), 2.

23. Major Robert A. Rosenwald, *Operational Art and the Wargame: Play Now or Pay Later* (Fort Leavenworth, KS: School of Advanced Military Studies, United States Army Command and General Staff College, 1990), 9.

24. Air Force Wargaming Institute, *ACES Player Handbook*, 1.

25. Henry Ellington, *How to Design Educational Games and Simulations* (Aberdeen, Scotland: Robert Gordon's Institute of Technology, 1987), 5.

26. Patrick D. Allen, *Evolution of Models at the Warrior Preparation Center* (Santa Monica, CA: RAND Corporation, 1993), 12-24.

27. Peter P. Perla and Raymond T. Barrett, *Wargaming and Its Uses* (Alexandria, VA: Center for Naval Analysis, November 1984), 10.

28. Colonel Michael Heenan, *Educational Wargaming*, 5.

29. Ibid.

30. Major Michael Bland and others, Discussions at the Air Force Wargaming Institute, Maxwell Air Force Base, AL: November 1994 - April 1995.

31. Booz-Allen and Hamilton, *Strategic Analysis Simulation* (Arlington, VA: Booz-Allen and Hamilton, Inc., 1987), 2.

32. Lauren B. Resnick, *Education and Learning to Think* (Washington: National Academy Press, 1987), 3.

33. Booz-Allen and Hamilton, *Strategic Analysis Simulation*, 4.

34. Major Michael Bland and others, Discussions.

35. Joint Chiefs of Staff, *Catalog of Wargaming and Military Simulation Models*, Appendices 1-9.

36. Armed Forces Staff College, *Joint AFSC Wargaming System Players Manual*, Volume I (Norfolk, VA: National Defense University, 1991), 15.

37. Bruce W. Bennet and others, *Joint Integrated Contingency Model (JICM) 1.0 Summary* (Santa Monica, CA: The RAND Corporation, August 1994), xvii.

38. Ibid., 200-201.

39. Ibid., 90-112.

40. Air Force Wargaming Institute, *ACES System Reports* (Maxwell Air Force Base, AL: Air Force Wargaming Institute, January 1995).

41. Air Force Wargaming Institute, *ACES Player Handbook*, 8-11

42. Headquarters Department of the Army, *Operations*, Field Manual 100-5, Chapter 2.

43. Department of the Air Force, *JFACC Primer*, (Second Edition) (Washington: Deputy Chief of Staff, Plans and Operations, HQ USAF, February 1994), 21.

44. Joint Chiefs of Staff, *Catalog of Wargaming and Military Simulation Models*, 221.

45. Major Michael Bland and others, Discussions.

46. Department of the Navy, *Naval Warfare*, Naval Doctrine Publication 1 (Washington: Government Printing Office, 1994), 65.

47. Mark Lambert, *Jane s - All The World s Aircraft* (Surrey, UK: Sentinel House, 1994), 614.

48. Richard Sharpe, *Jane s - Fighting Ships* (Surrey, UK: Sentinel House, 1994), 797.

49. Ibid.

50. Mark Lambert, *Jane s - All The World s Aircraft*, 554.

51. Air University, *Employment of Navy and Marine Forces,* Air University Publication 16 (Maxwell Air Force Base, AL: Air University Press, 1994), 35-38.

52. Ibid., 35.

53. Ibid., 36.

54. Ibid., 37.

55. Ibid.

56. Ibid., 29.

57. Department of the Navy, *Naval Warfare*, 66.

58. Richard Sharpe, *Jane s - Fighting Ships,* 786.

59. E.R. Hooten, *Jane s - Naval Weapon Systems* (Surrey, UK: Sentinel House, 1994), SM2.

60. Department of the Navy, *Naval Warfare*, 67.

61. Air University, *Employment of Navy and Marine Forces*, 67.

62. Ibid., 41.

63. Richard Sharpe, *Jane s - Fighting Ships*, 382.

64. Ibid., 383.

65. Ibid., 384.

66. Ibid., 387.

67. Ibid., 317-318.

68. Ibid., 309.

69. Ibid., 314.

Bibliography

Air Force Wargaming Institute. *ACES Player Handbook.* Maxwell Air Force Base, AL: Air University College of Aerospace Doctrine, Research, and Education, April 1994.

Air Force Wargaming Institute. *ACES System Reports.* Maxwell Air Force Base, AL: Air Force Wargaming Institute, January 1995.

Air University. *Employment of Navy and Marine Forces,* Air University Publication 16. Maxwell Air Force Base, AL: Air University Press, 1994.

Allen, Patrick D. *Evolution of Models at the Warrior Preparation Center.* Santa Monica, CA: RAND Corporation, 1993.

Anderson, Lowell B. and John H. Cushman. *A Taxonomy for Warfare Simulation.* Alexandria, VA: Military Operations Research Society, October 1989.

Armed Forces Staff College. *Joint AFSC Wargaming System Players Manual,* Volume I. Norfolk, VA: National Defense University, 1991.

Bennet, Bruce W. and others. *Joint Integrated Contingency Model (JICM) 1.0 Summary.* Santa Monica, CA: The RAND Corporation, August 1994.

Bland, Michael and others, Discussions at the Air Force Wargaming Institute, November 1994 - April 1995.

Boocock, Sarane S. and E.O. Schild. *Simulation Games in Learning.* Beverly Hills, CA: Sage Publications, 1988.

Booz-Allen and Hamilton. *Strategic Analysis Simulation.* Arlington, VA: Booz-Allen and Hamilton, Inc., 1987.

Decosta, Elena M. "Metacognition and Higher Order Thinking: An Interdisciplinarian Approach to Critical Thinking in the Humanities," *Thinking Across the Disciplines, The Proceedings of the Annual Conference of the International Society for Individualized Instruction,* October 1986.

Department of the Air Force. *Basic Aerospace Doctrine of the United States Air Force,* Air Force Manual 1-1, Volume II. Washington: HQ USAF, March 1992.

Department of the Air Force. *JFACC Primer* (Second Edition). Washington: Deputy Chief of Staff, Plans and Operations, HQ USAF, February 1994.

Department of the Navy. *Naval Warfare,* Naval Doctrine Publication 1. Washington: Government Printing Office, 1994.

Dunnigan, James. *The Complete Wargames Handbook* (Revised Edition). New York: Quill William Morrow, 1992.

Ellington, Henry. *How to Design Educational Games and Simulations*. Aberdeen, Scotland: Robert Gordon's Institute of Technology, 1987.

Glaser, Robert. "Education and Thinking: The Role of Knowledge, *American Psychologist*: 64-70 (February 1984).

Headquarters, Department of the Army. *Operations*, Field Manual 100-5. Fort Monroe, VA: US Army Training and Doctrine Command, June 1993.

Heenan, Michael E. *Educational Wargaming*. Maxwell Air Force Base, AL: Air Force Wargaming Institute, January 1992.

Hilgard, Ernest R. and Gordon H. Bower. *Theories of Learning*. New York: Appleton Century Craft, 1986.

Hooten, E.R. *Jane s - Naval Weapon Systems*. Surrey, UK: Sentinel House, 1994.

Joint Chiefs of Staff. *Catalog of Wargaming and Military Simulation Models*. Washington: Government Printing Office, March 1994.

Joint Chiefs of Staff. *Dictionary of Military and Associated Terms,* Joint Publication 1-02. Washington: US Government Printing Office, 23 March 1994.

Joint Chiefs of Staff. *Joint Modeling and Simulation Strategy*. Washington: The Joint Staff Deputy Director for Technical Operations, May 1993.

Joint Chiefs of Staff. *Joint Warfare of the US Armed Forces*, Joint Publication 1. Washington: US Government Printing Office, 11 November 1991.

Joint Chiefs of Staff. *Military Education Policy,* Chairman's Memorandum 344-90. Washington: The Joint Staff Deputy Director for Manpower and Personnel, 14 April 1990.

Lambert, Mark. *Jane s - All The World s Aircraft*. Surrey, UK: Sentinel House, 1994.

Masland, John W. and Laurence Radway. *Soldiers and Scholars*. Princeton, NJ: Princeton University Press, 1977.

Perkins D. N. and Gavriel Salomon. "Are Cognitive Skills Context Bound?," *Educational Researcher*: 17-24 (January-February 1989).

Perla, Peter P. *The Art of Wargaming*. Annapolis, MD: United States Naval Institute, 1990.

Perla, Peter P. and Raymond T. Barrett. *Wargaming and Its Uses*. Alexandria, VA: Center for Naval Analysis, November 1984.

Perla, Peter P. "A Guide to Navy Wargaming," *Wargaming Anthology*, Ed. Center for Naval Warfare Studies. Newport, RI: US Naval War College, 1991.

Resnick, Lauren B. *Education and Learning to Think*. Washington: National Academy Press, 1987.

Rosenwald, Robert A. *Operational Art and the Wargame: Play Now or Pay Later*. Fort Leavenworth, KS: School of Advanced Military Studies, United States Army Command and General Staff College, 1990 (AD-A233 925).

Sharpe, Richard. *Jane s - Fighting Ships*. Surrey, UK: Sentinel House, 1994.

Vita

Major Milan Celko received his commission in the Czechoslovak Air Force from the Air Force Academy in Košice in 1982, with a graduate degree in Machinery Engineering. His graduate work focused on NATO's air defense system against the Warsaw Pact, with special emphasis on the Patriot weapon system.

From 1982 to 1988, Major Celko served in the Antiaircraft Defense System as a pilot and flight commander in a MiG-21 squadron. In 1991 he graduated from the Military Academy, Brno. His latest assignment was as a MiG-29 squadron vice commander in the independent Slovak Republic. Upon graduation from Air Command and Staff College, Major Celko will return to duty in the Slovak Republic.

Lieutenant Commander Richard DuBois was commissioned through the ROTC program at Oregon State University in June of 1982. Designated a Naval Aviator in October of 1984, he reported to the Naval Air Station at Whidbey Island, Washington to begin initial fleet training in the EA-6B Prowler electronic warfare aircraft.

Upon completion of training, LCDR DuBois reported to the Rooks of VAQ-137, where he made two extended deployments aboard the *USS Saratoga*. In October of 1985, while deployed to the Mediterranean, the squadron was involved in the *Achille Lauro* hijack and rescue operation. During the period January to April 1986, his squadron participated in the Freedom of Navigation operations off of the coast of Libya.

In December of 1987, LCDR DuBois reported to the Vikings of VAQ-129 as an instructor pilot. While at VAQ-129, he taught weapons systems courses and worked in the Operations Department.

In September of 1990, LCDR DuBois reported back to sea duty, as a member of the VAQ-140 Patriots. Deploying aboard the *USS Eisenhower*, the squadron participated in United Nations peacekeeping duties in the Persian Gulf region. The cruise concluded with operations in the Mediterranean Sea and NATO exercises in the northern fjords of Norway. As Operations Officer, LCDR DuBois transitioned the squadron to the Navy's newest carrier, the *USS George Washington.* As Maintenance Officer, he deployed the squadron on the *Washington s* initial overseas cruise.

LCDR DuBois has accumulated over 3,000 flight hours and nearly 600 carrier arrested landings. He will complete his MBA at Troy State University Montgomery in June of 1995. Upon graduation from Air Command and Staff College, he will be assigned to the United States Strategic Command, Offutt Air Force Base, NE.

Major Scott Goehring [redacted]. He graduated from Hayward High School in Hayward, Wisconsin in 1978. He attended the University of Wisconsin at Superior and received Bachelor of Science degrees in Mathematics and Geography in May, 1982. He was a Distinguished Graduate from the AFROTC program and received his commission in May 1982.

After graduation, he was assigned to Grand Forks AFB, ND where he served as a Missile Launch Officer in the Minuteman III weapon system. He served as an instructor, an Emergency War Order Training Officer, and had the distinction of winning the 1987 SAC Missile Combat Competition, earning recognition as the Best Missile Combat Crew Commander in the Strategic Air Command. He complete a Masters degree in Business Administration from the University of North Dakota in July 1987.

In 1988, he was assigned to Vandenberg AFB, CA to the TOP HAND program for the purpose of conducting operational test launches of Peacekeeper and Minuteman ICBMs. From August 1991 through March 1993 he attended the Graduate Strategic and Tactical Operation Research Program, School of Engineering, Air Force Institute of Technology, Wright-Patterson AFB, OH, completing a second Masters degree in Operations Research. He was assigned to the Air Force Wargaming Institute, Maxwell AFB, AL as Chief of Wargaming Simulation with primary responsibility for the combat and movement algorithms of the ACES wargame. He was promoted to Major two years below-the-zone in May 1993. Upon graduation from Air Command and Staff College, Major Goehring will be assigned to the United States Strategic Command, Offutt Air Force Base, NE.

Major Michael T. McNeely [redacted] and graduated from Norwood High School in May 1976. He graduated from Lowell University, Lowell, MA in 1980 with a Bachelors Degree in Political Science and received his Masters Degree in Personnel Management from Central Michigan University in 1984.

After graduating from Lowell, Major McNeely attended Undergraduate Missile Training at Vandenberg AFB, CA and graduated in June 1981. He was assigned to the 321st Strategic Missile Wing, Grand Forks AFB, ND from June 1981 to September 1984 where he served in various positions in missile operations.

In October 1984, he attended Ground Launched Cruise Missile (GLCM) Initial Qualification Training at Davis-Monthan AFB, AZ and was assigned to the 501st Tactical Missile Wing, RAF Greenham Common, England. In October 1987, he was selected as a Command Inspector, United States Air Forces in Europe (USAFE) Inspector General team, Ramstein AB, GE where he led the GLCM inspection program.

Major McNeely returned from overseas in February 1990 and was assigned to the 90th Missile Wing, F. E. Warren AFB, WY as Chief, Training Branch, Missile Control Division. In October 1990, he was selected as an Assistant Operations Officer for the 319th Missile Squadron. During his time in the 319th, his squadron was selected as "Best ICBM Squadron" in the Strategic Air Command for 1991. In March, 1992 Major McNeely was assigned as Chief, EWO Plans and Targeting Section and took over responsibility for the largest target inventory in AF Space Command. Upon graduation from Air Command and Staff College, Major McNeely will be assigned to the United States Space Command, Peterson Air Force Base, CO.

Major Michael Webb [redacted].

He graduated from the Pennsylvania State University in 1980 with a Bachelors Degree in Mathematics and was commissioned through Air Force ROTC in August 1980. He began his Air Force career as a Minuteman II launch officer at Whiteman Air Force Base, Missouri. He continued his career with assignments at Royal Air Force Greenham Common, United Kingdom and Ramstein Air Base, Germany in the Ground Launched Cruise Missile system. He served in a variety of positions in missile operations, logistics, and intelligence.

Major Webb earned a Master of Science Degree in Management from Troy State University in 1986 and a Master of Science Degree in Operations Research from the Air Force Institute of Technology (AFIT) in 1990. Major Webb was a distinguished graduate from AFIT and was awarded the Mervin E. Gross Award as the top graduate from the AFIT School of Engineering. He is a graduate of Squadron Officer School and the Armed Forces Staff College Phase II Joint Professional Military Education Program.

Prior to attending Air Command and Staff College (ACSC), Major Webb served as a command, control, communications, computers, and intelligence (C4I) systems analyst for the Directorate, C4I Systems, United States Strategic Command, Offutt Air Force Base, Nebraska. Upon graduation from Air Command and Staff College, Major Webb will serve as Crisis Operations Officer, Defense Intelligence Agency, Washington, DC.

Major Webb is married to the former Elizabeth A. [redacted] of Seymour, Missouri. They have one son, Christopher, born 29 October 1992.